S. HRG. 100-846

ADVANCED REACTOR DEVELOPMENT PROGRAM

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

SECOND SESSION

ON THE

DEPARTMENT OF ENERGY'S NUCLEAR REACTOR AND SPACE NUCLEAR POWER RESEARCH AND DEVELOPMENT PROGRAM

MAY 24, 1988

Printed for the use of the
Committee on Energy and Natural Resources

U.S. GOVERNMENT PRINTING OFFICE

90-379 WASHINGTON : 1988

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

S311-17

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ADVANCED REACTOR DEVELOPMENT PROGRAM

TUESDAY, MAY 24, 1988

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met at 9:35 a.m. in Room SD-366, Dirksen Senate Office Building, Hon. J. Bennett Johnston (chairman) presiding.

OPENING STATEMENT OF HON. J. BENNETT JOHNSTON, U.S. SENATOR FROM LOUISIANA

The CHAIRMAN. Today the Subcommittee on Energy Research and Development is conducting a hearing on the Department of Energy's nuclear reactor research and development program. I congratulate the Subcommittee Chairman, Senator Ford, for scheduling this important hearing.

It is essential that we preserve the nuclear option in the United States, where over 100 nuclear plants are operating in this country, producing 18 percent of our total supply of electricity.

Most of those plants will continue to operate for some time into the future. We will also need to build new nuclear plants that will be ready to produce power in the next century. We will need 100 gigawatts of new generating capacity by the year 2000, assuming a two percent growth rate.

That is the equivalent of 100 nuclear plants of 1,000 megawatts each. But that is just a conservative estimate. Most projections would indicate a higher than two percent growth rate, and obviously if that growth rate is four percent then you would need 200 1,000 megawatt plants.

In order to be ready to build new plants, we must be sure that the technology is proven and that there is a product on the shelf to be built. Utilities need to be sure that the product will be licensable and cost effective, and that it will satisfy public concerns about safety and the environment. We need to plan now to be able to meet these needs in the future.

Annual funding for the Department's nuclear energy R&D program is approximately $350 million. I am concerned, however, that an increasing percentage of that funding is being directed towards space and defense needs. More than 40 percent of the Department's fiscal year 1989 budget request is directed toward R&D to support space and defense programs. A dollar spent on these programs is a dollar taken away from civilian reactor R&D.

Federal budget resources will continue to be limited for the foreseeable future. These resources will have to serve the needs of both the civilian and the defense sectors.

We simply cannot afford to ignore the need for a federal role in development of a new civilian reactor technology. I am concerned that the Department's program is not currently focused enough in the civilian R&D area. I am concerned that the continuing shift in direction away from civilian needs and towards space and defense needs will result in not having a new commercial product available when we need it.

I have stated in the past my intention to introduce legislation to help ensure that a new commercial product will be available in the future. As a matter of fact, we have been talking about that for some time on this Committee.

I hope that our witnesses today will address whether such legislation is necessary to focus on our civilian R&D programs. If there are other ways to accomplish this desired goal, I hope they will tell us that.

The idea is to get a—well, I guess the word would be—passively safe reactor, which is not to make a judgment on the safety vel non of existing reactors. Their safety record is quite enviable indeed.

But it is to recognize that the economics of present reactors, given public attitudes toward those reactors, make it difficult to build, particularly in today's regulatory atmosphere.

And if we can produce in this country a passively safe reactor which not only has demonstrable safety characteristics, but which appears to the public to be safe and therefore is capable of being more quickly and more easily both manufactured, probably in modules at the manufacturing site, and licensed with equal alacrity, then we could perhaps revive a nuclear industry, with a very good result for the country.

So I look forward to today's hearing. It will be a great pleasure to hear from our old friend, Dr. Jim Schlesinger. It's sort of like the old days. We had such a good time back in the energy crisis, we almost wish for its return, but not quite.

Senator McClure.

Senator MCCLURE. I wonder if I might defer to the Subcommittee Chairman first.

Senator FORD. No, go right ahead. The ranking always outranks.

STATEMENT OF HON. JAMES A. McCLURE, U.S. SENATOR FROM IDAHO

Senator MCCLURE. Well, I had better be careful of that.

I want to supplement what the Chairman has said, because I think today's hearing will provide us with the opportunity to view the Energy Department's program in nuclear research and development and to get some feedback from the private sector as to how the response to that program is to the needs of the nation's utilities, who must ultimately provide new, reliable baseload capacity in the not too distant future.

I would hope that we can take a statesmanlike approach this morning and devote our time primarily to discussions on the means by which the Department can bring various advanced reactor op-

tions to commercial availability, rather than once again reiterating the obvious institutional obstacles to the future use of nuclear power.

I agree with what the Chairman has said with respect to the legislation which we have discussed at various times, and I hope that we will be able to introduce that legislation. I hope these hearings will help focus on some of the things that we should do.

But there are some institutional problems, and I would like to make a few observations about the institutional problems. I am sure that everyone in this room has already heard about and would agree with the need for licensing reform and the adoption of standardized plant designs.

That is somewhat different from the subject that the Chairman was referring to, on which I agree with him totally.

Towards the end of trying to find some help in statute with licensing reform and the adoption of standardized plant designs, I will introduce legislation today that would facilitate the use of standardized plant designs and the pre-approval of plant sites.

Other institutional hurdles, including NRC reorganization and the reallocation of the planning and risk burdens that a utility now shoulders, are being addressed either in the legislation branch or the regulatory arena. And let me underscore that I think both of those need to be addressed, and I hope in a positive way.

With these institutional reforms, we will be successful in removing significant institutional roadblocks to the future use of nuclear power. But even with these needed reforms, we need better designs to deploy, and that is the area where the Chairman and I have had some discussions.

I would not expect any utility in the foreseeable future to select a custom made 1200 megawatt nuclear power plant as its preferred baseload plant. For one thing, large baseload plants, whether they are nuclear or coal-fired, are much harder to fit into the low growth curves we have experienced over the last decade, and bring with them—that mismatch brings a host of institutional and financial problems as it fits with state regulatory processes.

For another, these plants are complex and are subject to a first-of-kind learning syndrome, with all of the attendant delays and licensing uncertainties.

Lastly, these large plants are extremely capital intensive and can expose individual utilities to an inordinate capital risk, just from the perspective of the cost of money over time, let alone from the Monday morning quarterback tendencies of most utility regulators.

The technological advances attendant in the reactor concepts being pursued by the Department, the industry, and EPRI hold a great deal of promise for second generation nuclear power plants.

We are all very anxious to hear from the Department concerning the status of their programs in advanced light water reactors, high temperature gas reactors, and liquid metal reactors.

More importantly, we are anxious to probe the more difficult areas of how to pace these programs, what the Federal role ought to be, how to fund the necessary research and design work, and whether and how to fund the first prototypical demonstration plant.

There is no doubt in my mind that each of these emerging technologies will have a niche in meeting future power needs. But getting a program from the conceptual paperwork stage to the actual hardware stage is often a large, tortuous, and expensive path, unless certain goals are set and certain commitments are adhered to.

Unfortunately, the uncertainties inherent in annual appropriations, budgetary restraints, and changes in leadership make long-term commitments less meaningful unless the promises and progress embodied in the program can outpace and overshadow these uncertainties.

If we can bring to the program a clear commitment on behalf of the utilities and the suppliers and ultimately the consumers, then I think we will have the kind of momentum we need to produce some real winners.

With or without guiding legislation, I believe the advanced reactor program can make some real contributions, provided we all remain committed to a national energy program that includes the nuclear power option.

I thank you, Mr. Chairman. I thank you and Senator Ford as well for permitting me the time to make this statement.

The CHAIRMAN. Senator Ford.

STATEMENT OF HON. WENDELL H. FORD, U.S. SENATOR FROM KENTUCKY

Senator FORD. Thank you, Mr. Chairman, and my good friend the ranking member. It is always good to be with both of you and to show evidence of concern and apparent need for interest in this particular program.

The hearing today is basically the Department of Energy's program of research and development in nuclear energy. And for fiscal year 1989, the Administration has requested approximately $350 million for this program.

In this program we are talking about research to make these existing light water nuclear reactors safer and to extend their lifetime of operation.

We are also talking about designing an advanced light water reactor so that a better version of the current nuclear reactor technology can be made available when utilities want it.

We are talking about developing new nuclear reactor technologies—the high temperature gas-cooled reactor and the liquid metal reactor.

We are also talking about power sources for the strategic defense initiative, research that really has nothing—and I underscore, nothing—to do with making electricity for homes, businesses, or industry. Perhaps one-third to one-half of the $350 million is research that is primarily defense or space-related.

The purpose of this hearing in my opinion is to review this program and to receive testimony on where it is going. One of the problems is that it is not clear where the program is going.

Five years ago, it was headed towards the construction of the Clinch River breeder reactor. That was the focus of the program.

We were going to demonstrate that a liquid metal breeder reactor could produce electricity for the utility grid.

Then the Clinch River breeder was cancelled. So the focus in my opinion has been lost. Today we are paying for research and supporting facilities built for the breeder program.

The program and the facilities are expensive, too expensive if we cannot say what the taxpayers are going to get for their money or when they might receive it. If nothing changes, the money available to develop the next generation of civilian nuclear reactors will erode year by year.

That erosion in my opinion is going on now. The SDI is now getting a bigger and bigger share of the attention of these programs and facilities and a bigger and bigger share of the money.

The Energy Research Advisory Board has warned that mixing defense and civilian nuclear programs would not be good for civilian reactor research. If that is not true, I hope that some will advise us this morning.

These thoughts will make some people nervous. Today everyone in the reactor research program is looking out for himself. Programs in that condition in my opinion rarely produce useful results.

And I would say, looking at the audience this morning, that three-fifths of them are getting $300 an hour, and if we stay much longer they may get a million dollars, if you add it up, today to be here to listen to this testimony, Mr. Chairman. And it is interesting how you can draw a crowd.

I hope this hearing can help us see past these natural instincts of preservation to devise a program that will produce useful results. We need nuclear and we need coal and we need good strong research and development and demonstration programs for both of them.

And Mr. Chairman, I look forward to the testimony this morning.

The CHAIRMAN. Further comments?

Senator Evans.

STATEMENT OF HON. DANIEL J. EVANS, U.S. SENATOR FROM WASHINGTON

Senator EVANS. Mr. Chairman, just very briefly. I have no prepared opening statement, but a comment or two on the frustration I have found over the last five years, where we have zigged and zagged from emphasis on clean coal technology to money spent on a breeder reactor, which was then cancelled.

We have had our difficulties, and hopefully just this year have finally begun to make some progress on the waste disposal of our nuclear reactors. We have an off-again, on-again research and development program in alternative energy sources, usually off again when the Administration refuses to spend and on again when we insist that they spend in certain areas.

Too little attention is given to conservation and efficiencies in all forms of energy use. We have yet to fully identify and to fold into the economic equation all of the environmental costs of each form of energy production.

And we have finally arrived at a point where utilities for the most part are paralyzed and unwilling to invest in major new base plants. It is almost as if every current utility executive wants to get to retirement before they have to make big decisions which might prove to be dangerous for the company, but may be necessary for our next generation.

Mr. Chairman, I think that it is important for us to not only have this hearing, but beyond the hearing try to develop a comprehensive and consistent idea of what we want to do insofar as Congress has a role to play in this entire field.

I think we are all dismayed by the current state of not only the nuclear industry, but energy production generally. And yet, I suspect that we are as responsible as anyone because of the zigs and zags and frequent turns we have made in policy over the last half dozen years here at the Congressional level.

And I do not know how we get there, but I hope that through this hearing and through the activities of this Committee and ultimately the Congress as a whole we develop a more consistent and long term and long range set of policies that will help guide the rest of the country and maybe help in the process to unparalyze our utilities.

The CHAIRMAN. Senator Hecht.

STATEMENT OF HON. CHIC HECHT, U.S. SENATOR FROM NEVADA

Senator HECHT. Thank you, Mr. Chairman.

Just to say I have great respect for our next witness and I am anxious to hear what he has to say. It is sort of like Paine Webber. When you speak, sir, I listen.

The CHAIRMAN. Thank you very much, Senator Hecht.

Dr. Schlesinger, welcome to the Committee. We have of course asked that you review the need for an overall energy policy, including nuclear. We happened in our opening statements to have zeroed in more on nuclear, but we of course have solicited your comments on all the energy policy.

And we are very pleased and honored to have you back. Dr. Schlesinger.

STATEMENT OF HON. JAMES R. SCHLESINGER

Dr. SCHLESINGER. Well, thank you, Mr. Chairman and members of the Committee.

I should say at the outset that even when one is away from the issue of energy policy for some time, that the conflicting goals, the changes and so forth, all give it a kind of element of familiarity when one comes back to it.

Senator MCCLURE. Do you mean by that that you can come back to it and feel like you really have not missed much?

Dr. SCHLESINGER. I have not been away for a moment.

The CHAIRMAN. As we say in south Louisiana, la plus ca change, la plus c'est la meme chose.

Senator BUMPERS. Would you repeat that, please, Mr. Chairman?

I had a minor in French, Mr. Secretary, but I did not get that.

The CHAIRMAN. The more things change, the more they stay the same.

Senator MCCLURE. And Senator Evans, I trust that the Congress will not take too much of the blame for the difficulties in national energy policy. In a world of great flux, Congress is an element of relative stability, despite the vast changes that we see in public attitudes which drive all and in attitudes of the executive branch.

Dr. SCHLESINGER. Mr. Chairman, I had come prepared to talk about national energy policy and to talk to you about the oil market and what is going on in the Persian Gulf, the relationship between the two. I think I will abbreviate those comments and foreshorten my own introductory observations.

Mr. Chairman, it is not precisely right to talk of the need for a national energy policy. We always have an energy policy, even if it is a haphazard policy. Laissez faire is an energy policy. Drift or do nothing are energy policies.

We have an energy policy today. The actual, if unintended, energy policy of the United States is growing energy dependence. That is our de facto policy. We have abandoned the quest of the decade of the seventies for national energy independence.

And in the 1990's we will, I fear, as a country and as a superpower pay a high price for that.

Mr. Chairman, I want to make a few comments about the oil market, but I will abbreviate them. Consumption is rising rapidly, more rapidly than the statistics that are presented at the international or the national level allow. Oil consumption is rising worldwide by a million barrels a year. Our imports have risen by some 50 percent over the last two years.

They now reach a total of seven million barrels a day, total imports, and net imports are 6.3 million barrels a day. Production continues to fall. It will fall more rapidly because of the low rig count. On the North Slope, the long deferred start of the decline in the Prudhoe Bay reservoir will start certainly by 1990.

So that even as we close out 1990, we face the prospect of imports at the eight million barrel a day level, close to the record. By the middle 1990's, we face the prospect of imports at the 13 or 14 million barrel a day record level, if it is available.

And we should note that oil production in the United States by that time will have fallen to six million barrels a day. We will be overwhelmingly dependent upon imports, an embarrassing position for a great power.

As you will have noted, the balance of payments of the United States is not entirely in good state. We have a massive merchandise trade deficit, and that will grow rapidly in the 1990's as the cost of our oil imports rises from $40 billion a year to $120 billion a year by the middle 1990's.

The call on OPEC is now approaching 20 million barrels a day. In the past, that 20 million barrels a day has been regarded as the magic point that would permit OPEC to start raising prices.

Moreover, we are approaching the 80 percent of OPEC capacity, as defined by the Department of Energy, and by 1990 or 1991 we will have reached that 80 percent of capacity, such that OPEC's control over world prices will be re-established.

I think it is fair to say, Mr. Chairman, that one can expect no change in the international oil market in the near term, despite the forthcoming meeting of OPEC. Nothing will occur. I think that

the Saudis are unlikely to antagonize those who provide security to them, namely the United States. And the Saudis are at this juncture preoccupied with the haj.

But the United States moves on. In the recent meeting at the Mexican embassy in London, just prior to the Geneva meeting of OPEC, one of the participants commented that, irrespective of the public problems that the United States represented, that the United States was doing for OPEC precisely what was required.

First, it was allowing large increments to domestic consumption, running now at almost four percent per annum, and allowing significant decrements to domestic production. In brief, the United States was doing more for the restoration of OPEC power than any other nation.

A policy of doing nothing with regard to oil in the short run means a greater national problem in the long run. As you all know, we are now engaged in naval activities in the Persian Gulf. These activities have taken place against the backdrop of a slack oil market.

Under different conditions, the freedom of decision of a President of the United States would be substantially altered. Even in 1980 when the Iran-Iraq War broke out, one will recall that panicky reaction because the importance of a slack oil market was not fully recognized.

The defense budget is now in the process of decline. It will have an impact on our conventional forces. It will have an impact on our defense posture. We will be less able in the middle 1990's to take the kinds of actions that we have taken in the Persian Gulf recently, just as our dependency on the Persian Gulf starts to rise.

Mr. Chairman, I should say a few things about electric power. There are serious prospective problems, as all of the introductory statements have indicated, in electric power supply in the 1990's.

This nation overstated, overextrapolated, electric power demand growth in the 1970's. We are now underestimating it, partly for the reasons that were pointed out by Senator McClure.

Last year, electric power demand grew by 4.5 percent. Over the course of the last six years, it has grown by 3.3 percent per annum on average, well above the level that is admitted by the industry, for a number of reasons, or by projections of the government.

We are already experiencing constraints. In New England, last winter we reached a peak that was not anticipated until 1994. In New England power demand is growing at five percent.

As some of the initial comments indicated, the purpose of utilities is to avoid commitments. A strategy of capital minimization is the guiding star for utility policy. Senior executives wish to avoid any new construction. And I believe that the enthusiasm that we see today for independent power production, for competition on the part of the utilities, on the part of some of the utilities, may reflect their desire to avoid new commitments and to impose the commitments for construction on somebody else, more than it does any confidence in the new procedures for providing electrical power that are being elaborated.

Utilities in the past have not been able to recover the costs invested in power plants. We have had a number of shocking cases of this sort.

Nuclear power in this country, the control of nuclear power, has been little short of a disgrace, a national disgrace, not, Senator Evans, if I may say so, primarily blamable on the Congress, but blamable on others.

France and Japan, making use of technologies developed by the United States, are doing splendidly with nuclear power. We will need the nuclear option in the 1990's, if for no other reason than as the public realizes the implication of the greenhouse effect, about which there is less and less scientific question.

And indeed, as the availability of domestic oil continues to decline, if we are to have a national energy policy we must have the nuclear option.

The conclusion, Mr. Chairman, with regard to national energy policy is that we must arrest the growth of oil imports if we are to continue to have the latitude of a great power. That means relying more upon domestic production. It is necessary for us to restore or revive the nuclear option, which is now moribund.

We are going to have serious problems in the 1990's. These are not publicly acknowledged today. It is an old statement that we are unable to recognize the handwriting on the wall until our backs are up against it. Let us see if we can recognize that handwriting on the wall and get a jump on the solution of our many energy problems.

I say this, Mr. Chairman, in an exhortatory manner. I am not optimistic that anything substantial will be done in the near term. Nothing clearly is going to occur until after the election and when one has a new Administration, whichever party wins the election.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Dr. Schlesinger, for a really excellent presentation, virtually every word of which I agree with.

May I first of all very briefly go down a shopping list of some things that have been proposed which would make——

Dr. SCHLESINGER. Mr. Chairman, might I interrupt you and offer just one more word following up some of the observations of Senator McClure.

I think that we ought to have the hardware possibilities in place, but we must recognize that in order to cure what is a national disgrace we are going to have to have institutional reform soon. A board of directors that chose a nuclear plant today would probably be sued by its stockholders for irresponsibility, quite rightly, given the problems that have been created.

We are going to have to have that licensing reform. We are going to have to straighten out the conflict between state and federal jurisdiction. At one time the federal government had primacy in this area. That has been cast under the shadow by the reforms that came after Three Mile Island.

That will have to be re-established if nuclear power is to have a chance. Moreover, licensing reform is an old question. It is an old question.

As Senator McClure and others will recall, in the bill that I sent up some years ago there was a provision in there called res judicata. That means that once an issue has been resolved in the hearing

process, it cannot be raised again. As we know, in the hearing process issues are raised, re-raised, re-raised.

As a result, we have delays, deferrals, that add astronomically to the costs. When those costs go up, state regulatory bodies proceed with prudency hearings and deny cost recovery to the utility.

Under these circumstances, we cannot have much change. I think, irrespective of the need to move forward with new reactor types, that we must understand that the priority rests on clearing up what has become the total snafu in the licensing area.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Dr. Schlesinger. Dr. Schlesinger, two of the things that have been suggested to deal with the problem are, first of all, drilling on the Arctic National Wildlife Refuge, and secondly, an oil import fee.

Would you comment very briefly on those two proposals?

Dr. SCHLESINGER. Mr. Chairman, I think that we ought to proceed with exploration right now on the wildlife refuge on the North Slope. If the exploration shows that there is no oil there, which I would hope would not be the case, then the problem is resolved with regard to development activity.

I would propose that if there is oil there, that we proceed to develop it. But others, as you know well, Mr. Chairman, will take a different view. But that issue can be deferred, whether or not to develop. We ought to know what kind of resources are up there if we are to have a national energy policy that makes sense.

With respect to the oil import fee, I am sympathetic. I would prefer to do these things, Mr. Chairman, through the federal tax code. I think that we should have a variable depletion allowance that rises when oil prices, as they have in recent years, plummet, such that one has greater stability for the industry.

I would encourage you to look at the same time at an exploration bank to help sustain exploration during periods such as now, in which it is difficult to achieve. And I myself would be prepared, if I may use the word, to subsidize exploration, not development, so that we have a better feel for the resources that we have.

I have some sympathy, although I prefer to do it in other manners, for an import fee. I would certainly have a floor price, so the producers understand that they are not faced with the uncertainties that are driven by the internal politics of the Persian Gulf, in addition to the internal politics of OPEC.

At the present time we have a very low rate of drilling activity. It could be enhanced if there were greater confidence.

If there were a political base for an oil import fee, I might be even more supportive.

The CHAIRMAN. I think your first and last statements are correct, that it is a good idea, but there may not be the political base at this time.

Dr. Schlesinger, with respect to the nuclear option, give us your view on the present light water reactor, first as it exists and secondly as it might be improved, as opposed to the other kinds of what are called passively safe reactors, those that would give you reaction time, maybe graphite-moderated or gas, HTGR's, several of those different types?

Would you give us your views on which of those means we should pursue?

Dr. SCHLESINGER. Yes, sir. Let me start with the following observation. The light water reactor is at the present time perfectly fine for deployment in the United States.

You mentioned the problems with public opinion, that I shall come back, but let me stress that. Every industrial country in the world is proceeding with the deployment of the light water reactor as originally designed by American technologists: the Japanese; French foremost; Britain, the U.K., which a decade ago turned to gas-cooled reactors, has made the switch and is moving towards Westinghouse technology, pressurized water reactor, and will deploy those pressurized water reactors.

Those are being deployed in Germany. So that the technology is regarded universally as safe, even in countries with a much higher population density than the United States has.

This in no way detracts from the efforts of this Committee to proceed with further improvements in the technology. But I must say that the problems with the pressurized water reactors are more the problems of domestic politics and the privilege in the United States of each group having its day in court to the extent that we have provided the basis for a kind of guerrilla warfare that precludes timely deployment, timely construction and startup of the light water reactor.

The problem is basically one of getting a better regime in which we can deploy reactors. But we can certainly move on.

You mentioned the possibility, and I believe you will have testimony later in the day with regard to, reactors that depend less upon human reactions, less upon engineered safety features, reactors that will have more passive safety devices.

The industry is doing some of that, and I would certainly encourage you to support those kinds of ventures.

With regards to liquid metal, as you know, what drove the liquid metal breeder originally was the notion that we were going to run out of uranium ore. That is not, as the Supreme Court might have said, a clear and present danger. The rate of startup of nuclear reactors is much slower, the supplies of natural uranium much larger.

I believe that the breeder can be deferred by the United States and that we have nearer term problems. I do not want to say matters adverse to gas-cooled. I believe that the technology is worth exploring, but I think that one must recognize that pressurized water reactors are much further along than are gas-cooled and that those who have had experience, most notably the British, have moved back toward the light water reactor.

So I would be hesitant, it seems to me, under circumstances of this sort not to encourage the industry to move in that direction which seems most natural, to bring in new features into reactors that are passively safe.

The CHAIRMAN. Thank you, Dr. Schlesinger.

Senator McClure.

Senator MCCLURE. Thank you very much.

Dr. Schlesinger, I agree with what you have been saying and I commend you for continuing to say it. You have been absolutely

steadfast over the years. And while we talk about a lot of zigs and zags, I have not detected much deviation in what you have been presenting to this Committee and to the public. And I commend you for that.

One of the things that I have to be reminded of, and Senator Evans constantly reminds me of it, is the contributions that can be made by energy efficiencies and conservation. And I do not quarrel at all with the desirability of doing that where it is economically sound to do, and there are many opportunities in that field.

But in spite of the energy efficiencies and conservation advances that have been made over the last several years, electric consumption has been rising. And as I recall, the energy consumption for a number of years almost exactly paralleled economic growth, and then there was a period of time in which economic growth was greater than the increase in energy consumption.

There was not a direct one for one relationship. Now we again see electric energy consumption rising more rapidly than economic growth, and certainly about twice as rapidly as total energy consumption. And that is in the presence of some rather vigorous efforts on conservation and efficiency.

Do you anticipate that electricity consumption will continue to rise relative to the economy on a one to one relationship, or greater or lesser than that?

Dr. SCHLESINGER. Once again, let me endorse Senator Evans' comments about conservation, and perhaps most notably conservation in the petroleum area. Liquid fuels is the nation's biggest energy problem.

I believe, Senator McClure, that for the years immediately ahead that ~~we are~~ going to see electric power consumption rise more rapidly than the gross national product.

Why did we see that decline relative to GNP in the course of the late seventies and early eighties? Largely because of the movement of foreign-manufactured goods into the United States and the erosion of the domestic manufacturing base. That erosion went on for a long time until such point that we have a balance of trade deficit that reached at its peak $180 billion a year on an annualized basis.

The U.S. dollar has plunged. More importantly, it is not sustainable in the long run to have so large—even for the United States, it is not sustainable to have so large a trade deficit.

We are going to see the shrinkage of that trade deficit through the decline of the dollar. There will have to be more room made for the importation of foreign oil, both as the volumes and the price rise. And as a consequence, we are going to see the revival—we are seeing the revival; we will see the further revival of the American domestic manufacturing base.

And that means intensive use of electric power as the domestic manufacturing base revives. We will see a growth rate for electric power demand exceeding the GNP.

Senator MCCLURE. We have a very special relationship with our neighbor and trading partner to the north, our largest trading partner, our closest friend, a very important ally, and a country with whom we have very, very excellent relations.

We are talking about the enactment of a free trade agreement with the country of Canada.

Do energy imports from Canada have a different effect on balance of payments than energy imports from say Mexico or from the Persian Gulf?

Dr. SCHLESINGER. Let me augment that slightly by saying of course there is a security dimension as well, and the volatility, the political volatility of the Middle East, its proximity to the Soviet Union, make that a security problem in a way that neither Canada nor Mexico will be.

But more importantly, the increasing tendency among Persian Gulf nations has been to import more from Europe and Japan and less from the United States.

In the case of Canada, when there are out payments from the United States, the bulk of those out payments come back to us in the form of purchases by Canadian citizens. So the net drain of out payments is much less.

Mexico is more like Canada than it is like the Persian Gulf countries. So not only are the security problems less, but the implied economic problems are less when we deal with our immediate neighbors.

Senator MCCLURE. So there is less risk on security and economic grounds from increased imports of energy from our immediate neighbors than from other areas?

Dr. SCHLESINGER. Yes, sir.

Senator MCCLURE. Are we free of consequences, or is that just a reduced consequence of a balance of payments problem when we import more? What I am getting at, I guess—and I want to be very candid about it—is that there is a tendency both on the East Coast of the United States and the West Coast of the United States to look to Canada as the source of more and more electrical energy.

And the Canadians are eager to supply it. And I am really wondering what your opinion is as to that as a matter of national policy. Set aside the security question for a moment. I agree with you, it is less insecure, it is more secure supply.

Just comment a little more directly with respect to the growing volume of energy imports and what that does in terms of balance of payments.

Dr. SCHLESINGER. Of course it has a negative effect in terms of the balance, the balance of trade or the balance of payments. But it is less negative than it is in the case of imports from the Persian Gulf.

I would not particularly worry about imports from Canada, for the following reason, that I do not think we are going to have a very large proportion of our electric power supply imported from Canada. At the maximum it is going to be three or four percent of the total amount of electric power used in the United States.

Canadian capacity is not that large. There are limits for technical reasons to the amount of imports. Right now the Canadians are doing very nicely in expanding their trade, but that is in large degree because of our own folly. When the Americans make fools of themselves with regards to the regulatory system, the net effect is that the Canadians benefit.

In the 1960's and seventies, as you will recall, Senator, the Canadians expanded rapidly their natural gas imports to the United

States, which were in fact subsidized imports, because of the follies of our own regulatory system. The same thing is happening here.

I think that our obligation is to straighten out what we are doing so that utilities find it sensible to build their own capacity. I do not worry about the Canadians, the reliability of supply of Canada.

But I think that the dependency might—the demand for Canadian power might exceed what the Canadians will be prepared to supply over the long run, unless we are able to straighten out our own regulatory morass.

Senator McCLURE. I would say I have great confidence in the Canadian government, but they are subject to changes in direction of policy, as we are. It was only eight years ago that we indeed did have some problem with respect to security of supply of Canadian supplies flowing to the United States, and that has been corrected very recently as they sought to take advantage of markets here for their own benefit, not for ours.

And I would expect them to act in their own interests, not necessarily in ours. I think in the event of global conflict, they are a reliable friend. There are a lot of reasons why they would be. It would be in their interest and in ours.

And I salute them certainly, but I also remember very clearly the problems that we had eight or ten years ago with respect to Canadian policy on the availability of energy supplies and the security of those energy supplies at the very time we were having problems here.

They did not move to help our problems as we had a perceived natural gas shortage because they perceived the shortage for themselves, and they acted to protect their own future interests with respect to that perceived shortage, and that exacerbated our own perception of future shortage of natural gas supply.

Both they and we were wrong at that particular time. But nevertheless, their actions reinforced our problems. And I say that because I guess it is a way of saying that they neither will solve our problems nor create our problems, but neither can we rely upon them to bail us out of problems when they and we both have the same perceptions.

Dr. SCHLESINGER. Senator, could I add a few words on that? Indeed, the Canadians at that time had a very restrictive export policy for oil and for natural gas. And I do not exclude the possibility of a return of Canadian nationalism.

I will say this: that I know of no instance in which the Canadians have welched on a contract. If they had agreed to provide it contractually, they have delivered. So I think one could have some confidence in what they contract for, even though, as you point out, the overall policy is subject to revision.

And in the 1976-77 winter, the Canadians did throw aside their own restrictions on the export of natural gas when we had that natural gas shortage.

Senator McCLURE. They are capable——

Dr. SCHLESINGER. That was a short term response, to be sure.

Senator McCLURE. I would agree, too, that they do not welch on their agreements, and I salute them for that. But they are not above changing the tax consequences of those agreements in order to maximize income in their own provinces.

Thank you, Mr. Chairman.

The CHAIRMAN. Senator Ford.

Senator FORD. Thank you, Mr. Chairman.

I have been sitting here thinking. All but two of us here now worked with the Secretary during the energy crisis of the seventies. Some of us were driving fuel trucks around the state as governors to try to distribute oil to schools, and went through all of that.

And we remember. We remember.

Dr. SCHLESINGER. Senator, Senator Wirth was then in the House of Representatives and he was giving me hell from over there. So he worked with me. And Governor Evans at that time, we were working on the development of nuclear power. I can well recall traveling with President Nixon and Governor Evans during those early years.

Senator FORD. I was not privy to all the flying around with President Nixon. About the only thing I got from Air Force One is a little pad that says "My trip on Air Force One." Somebody gave it to me. I keep wishing and hoping for the day.

Dr. SCHLESINGER. It is a valid expenditure of DOD dollars, sir.

Senator FORD. Now you say that.

But I reflected just a little bit as we were talking. We are getting to the position where we are going to have to react again. We are not going to act, Mr. Chairman, as I see it based on where we are going, the drift, as you said it, of dependence.

What is it, almost 500,000 more barrels of oil per day this year in dependence than we were last year? And so we find ourselves sitting here hoping we can keep this ship afloat until somebody else will come and grab it for us.

But many people think, I am one of those and I think you are, too, that the 1990's will be a time when the conditions that led to the energy crisis of the seventies will reappear or be revisited again.

Mr. Secretary, if such a crisis should occur, what should in your opinion be the reaction of the U.S. government as it relates to our domestic policies?

Dr. SCHLESINGER. I think that we should be taking the preparatory steps now, but we probably will not, as you point out, Senator; and that we will be acting in haste, and it is always a mistake to act in haste. But we will act in haste.

We should move in the direction of switching to more available domestic fuels. That includes natural gas, although there is not an immense amount of augmentation.

Senator FORD. The glut of oil has given us a glut of natural gas, has it not?

Dr. SCHLESINGER. That is right. It is also the fact that we now price natural gas as something that people have to conserve, as opposed to giving it away, as was the case some years ago.

And we should move towards coal and nuclear power. The rules for energy policy are very simple: Conserve, substitute more available domestic fuels for less available ones that we will increasingly have to import, at great economic, military, and political embarrassment to the United States.

Senator FORD. You talk about the deficit in balance of trade, with roughly $45 billion of that last year being import of oil, and

going up. And I think your figure is $120 billion if we stay on the same trend line by the mid-nineties.

Dr. SCHLESINGER. In constant dollars.

Senator FORD. Nuclear energy—of course, I am from a coal state, but I understand all of the other options that we need to have. What in your opinion is the proper role of the federal government in getting the job done to see that—and you have touched on it maybe in two or three different ways.

But give us the proper role of the government in getting our nuclear power option in gear?

Dr. SCHLESINGER. The first point is simply to reiterate the need to end the institutional morass that the United States has uniquely created for its own nuclear industry. It is a national disgrace.

The second point is one that you raised in your introductory remarks, Senator. You said, if I caught it correctly, mixing defense and military reactor programs is not good for civilian programs. I would also say, it may not be good for the military program as well.

I think that we now have a prospect in which our whole deterrent, nuclear deterrent, rests upon the production from aging reactors that have been degraded, and that I believe that we should do something about it and do something about it reasonably quickly.

But I would hesitate to try and charge off into new technologies for that military reactor. It seems to me that at this stage what we ought to do is to follow the advice of the Glennan Committee that reported to Secretary Hodel four or five years ago with regard to that production reactor, what kind of reactor it should be.

If we attempt to piggyback on a military reactor new technologies, I think that we may defer the point that we have nuclear materials, special nuclear materials for the military, coming on line, and it will take a long time to introduce that reactor because of the problems of program definition phase and the like.

I remind the members of the Committee of this point that was made by Admiral Rickover in 1953, when he distinguished between paper reactors and real reactors, paper reactors being very easy, very cheap, easy to design, and so forth, because all you need is pencil and paper.

By contrast, real reactors, there are always delays, the costs tend to get larger, and so on.

Until one has a defined reactor that has been through program definition phase, if one wants to move ahead for military reasons one ought to go with what one already knows. And therefore, I think we should have a military production reactor.

To lump together the civilian program and the military program consequently could have a baleful effect on our military program, particularly given the dependency of the nuclear deterrent on the production of special nuclear materials now endangered.

With regard to the third point, Senator Ford, is that the United States government has a responsibility to provide research and development funds in areas of high national priority if those funds will not be forthcoming from industry, to supplement industry funds.

I think, given the state of the nuclear option in the United States today, we may not have a sufficient willingness on the part of the

nuclear industry to provide such funding for advanced reactor types. And therefore, it is a proper role for the U.S. government to do it.

Senator FORD. Thank you, Mr. Secretary.

Thank you, Mr. Chairman.

The CHAIRMAN. Senator Evans.

Senator EVANS. Thank you, Mr. Chairman.

First, in your comments I thought I heard you say that electrical load growth was a little over two percent over the last six years, more than admitted by either the industry or the government. I was curious about that comment and I wanted you to explain that.

Dr. SCHLESINGER. That may have been ambiguous. If you look at the projected growth rates and then compare the actual growth rates, after one passes a particular historical point the projected growth rates are much lower than the experienced growth rates.

Moreover, as one looks into the out years one sees projected growth rates much lower than the ones we have recently experienced. And that is due to——

Senator EVANS. That is just the reverse of the early seventies, where we were projecting growth rates that were much larger than those which actually occurred.

Dr. SCHLESINGER. We are now using for projecting electric power demand the gross national product growth rates of the 1970's, even though the gross national product is growing much more rapidly than it was in the seventies.

Senator EVANS. At least now. It just proves the impossibility of using a single line forecast for almost anything. And we ought to be prepared for—at least that is one thing in the Northwest power planning project. We decided at the very first that we were not going to use a single line forecast, because all you do is prove yourself wrong instantly and there were better ways to get at that.

Do you think that these rapid changes in the relationship of electric power use to gross national product, however, have been driven to a pretty fair degree by the rapid changes in basic materials?

We have seen a collapse of the aluminum and copper and other metals markets and now a revival of those, at least in our part of the country. That is a very heavy user of electricity. Has that been an unusually large factor in these changes, or can you identify other specific factors?

Dr. SCHLESINGER. No, those are the energy intensive industries. Those are the ones that have been under particular pressure as a result of foreign competition. Those are the ones reviving most rapidly as foreign competition eases.

Senator EVANS. But they will only revive to a certain degree. When they get to 100 percent capacity, they cannot revive any more. We are unlikely to see, at least in the near term future, the building of additional plants of that kind.

Will that not have potentially a dampening effect on the kind of growth rates in the future? In other words, we have got to analyze more carefully than we have done in the past what is most likely to happen in the future.

Dr. SCHLESINGER. Absolutely, Senator Evans. And I just did some broad-brush work. It is important to recognize the role of the rise

and fall of the trade deficit, but the components are equally important.

Indeed, we are not going to see the U.S., the United States steel industry producing 120 million tons again. But we will see a revival to 80 million or 75 million. But other manufacturers tend also, though less notably, to be heavy consumers of electric power compared to commercial or household users.

Senator EVANS. You talked about the possibility of delaying breeder reactor programs. But are we likely to run the same routine that we are now painfully going through in the petroleum industry, where we will blithely go ahead with an expansion and revitalization of the light water reactor, another generation of light water reactors, find ourselves sooner than we think at a point where the fuel itself becomes something of a problem, prices rise for fuel, and we will be back in the game of looking for the next generation, which may well be breeder reactor?

Should we at this point, at least from the Congressional viewpoint, restart the program in some fashion or re-expand the program? We are doing some things now.

Dr. SCHLESINGER. I would prefer to move in that direction, Senator. I was asked to prioritize, and if we had less budget pressure than we have at the present time I would be inclined to move ahead with development of breeder technology.

I think it can be deferred, but as your question implies, not endlessly deferred. We ought to get on with the job in the 1990's.

Senator EVANS. What is your current assessment of the place of fusion and its potential timing and the potential role that it might play in the future in electric production or in power production?

Dr. SCHLESINGER. I think that it may be available before judgment day, but I cannot guarantee it. I think that we are talking about an option on a commercialized basis that is 35, 40 years out if we are very lucky. And therefore, it does not constitute part of our current planning.

That does not mean that we do not put in research funds, but it is not a near term energy option.

Senator EVANS. Finally, you mentioned a very interesting idea on the subsidization of oil exploration in order to keep a more balanced program going. And it is an interesting option.

Would you suggest that if the government were to subsidize exploration, that they also take a financial position in the finds? In other words, if we are going to subsidize exploration and exploration leads to some healthy new sources, would it not be appropriate under those circumstances, just like another investor, to take a position in the end result?

Dr. SCHLESINGER. I think that that has merit, and I have not thought it through, but I would certainly be prepared to consider that.

Senator EVANS. I would hate to have us get involved in the management, but the financial position, it seems to me that that is probably a pretty good tradeoff.

Dr. SCHLESINGER. I mentioned the possibility of an exploration bank. Obviously, those loans would have to be repaid in the event of success on the part of——

Senator EVANS. That is a somewhat different thing, but you are also talking about the subsidization of exploration.

Dr. SCHLESINGER. I have not thought that through, and I would certainly think that that would have merit. It would, of course, somewhat reduce the incentive for those who tend to be plungers in this particular industry, and therefore we would have to look at that.

But I see no reason not to do that on principle.

Senator EVANS. Well, it seems to me that if a plunger does not have to plunge quite so deeply, he probably should not expect to come up quite so healthy. There is a balance in there that it seems to me makes some sense.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Evans.

Senator Bumpers.

Senator BUMPERS. Dr. Schlesinger, as I sit and listen to this I think about, among other things I did besides practice law was own a cemetery. It only took me a year to get out of it, because even with my considerable persuasive skills I could not sell cemetery lots to healthy people. And so it is with the energy policy.

When Ronald Reagan first came to power, you recall that the key to our energy policy was going to be that the government would involve itself in those areas where we had a national overriding concern, that the private sector would not pick up.

It has not happened that way. I agreed essentially with that philosophy, but it just has not happened. And the figures you put out—and I agree with most everything you said.

I am not sure that I agree with the nuclear option, not because it may not be technically correct, but because the American people simply have not yet accepted that idea and it is very difficult to get anything done around here that there is not some overwhelming consensus for in the country.

But let me just ask you this question. We have deficit problems and we have an energy consumption problem which is growing at a fairly alarming rate now. How would you feel about a 50 cent gas tax which, even taking into consideration the depression of demand that that would cause, it would produce somewhere between $40 and $50 billion, which the Treasury could certainly use in dealing with our fiscal problems?

And it most assuredly would cut consumption. We found out when gasoline went to $1.30 a gallon, we found that it is not price inelastic, as we had been led to believe here. We found that Detroit, even though we had to drag them kicking and screaming into it, are building more fuel efficient cars.

My point is simply this. I do not know that you could ever develop a consensus for this. The Europeans have it. I never thought I would even be suggesting it, being an Ozark Mountain populist.

But what would you think of such a proposal?

Dr. SCHLESINGER. I was for it in 1977. I am for it in 1988, Senator. As you may recall, that was part of the National Energy Act as proposed. I still have the black and blue marks all over me.

Senator BUMPERS. Probably some of them I inflicted.

Dr. SCHLESINGER. As a matter of fact, I have a recollection of that, too.

I think that it is highly desirable for conservation reasons and now for budgetary reasons.

Senator BUMPERS. And the third thing that I failed to mention was the trade deficit. It would have a dramatic impact on that immediately in my opinion.

Dr. SCHLESINGER. Yes, sir.

Senator BUMPERS. Would you favor putting the kind of tax rebate in to eliminate—or at least to give it some kind of progressivity?

Dr. SCHLESINGER. Yes, sir, I would. I would try to protect the poorest elements in the population from those effects.

Senator BUMPERS. Just rather quickly, what would you think about the United States government exploring ANWR, at least initially?

Dr. SCHLESINGER. I have no problem with that. You may not know this, but I was during my government career an oil driller at the Naval Petroleum Reserve No. 4, up there somewhere to the west of Prudhoe Bay. It was something that I drilled, eleven holes, all dry.

As a consequence, my enthusiasm for the government doing these things diminished. I was—there it was for many years, the basis of protecting the nation's oil supply in the event of war, and when we went to exploit the reserve there was nothing there. The cupboard was bare.

But I think that that is a perfectly acceptable way of doing it. We should recognize in the government what people in the oil industry have recognized, that the risks are high. And so if that is the way that it can be done and we can get the exploration and we know what the resources are up there, I would be all for it.

Senator BUMPERS. Let me ask you a question on an unrelated subject to what we are here about this morning, but one that is of increasing concern to me and the Chairman of this Committee, because we are both pretty much opposed to SDI.

But we now know that the Soviets have a Rorsat reactor coming down probably in the August-September time frame. And we also know that their ability to destruct the highly enriched uranium on board in space, that system has failed. They admit that.

There is 150 kilograms of highly enriched uranium on board. And let us just assume for the purposes of argument that one-fifth of the earth's land space is in the Middle East, so let us assume that it comes down in Libya. And this is a highly sealed package of enriched uranium, and let us assume that it does not burn up as it comes back into the atmosphere, which is a distinct possibility. We have hundreds of thousands of radioactive items in Canada from the other one in 1979.

And let us assume further that Kadafi can somehow or other find some people to extract two and a half pounds of that 150 pounds, which is about all it would take to make a weapon.

Is that a possibility or not?

Dr. SCHLESINGER. I do not know the status of the U-235. I do not know what the level of burnup is. Presumably, if the level of burnup is high one would have to have a chemical plant, a primitive chemical plant in order to separate out the U-235 that sur-

vives in there from the plutonium. One could do interesting things with the plutonium as well as with the U-235.

Indeed, it is a possibility if it comes down in Libya.

Senator BUMPERS. Let me ask you then a follow-up question. SDIO has not yet, understandably, made a decision as to what, if we go forward with SDI, what kind of power systems we are going to have and whether they are going to be deployed in space or on the ground, and so on.

But my guess right now, just based on what I believe—and this is not classified—there is a distinct possibility that, because of the compactness, the survivability, and the lifetime of a compact nuclear power plant, that at some point they almost certainly are going to be required to say that we have to put nuclear reactors in space in order to make the system work.

Now, right now they do not like to talk about it and they do not want to admit it, and I am not suggesting that the decision has been made. I am just simply saying, based on what I know, that we do not have—certainly we do not have the radioisotopes and we do not have the chemistry. We cannot design a solar system that will even come close to generating the kinds of power that we may very well like to have in space if we are serious about SDI.

And given the proposition that I just gave you a moment ago, if we had 12 to 25 plants up there with much, much more highly enriched uranium than the 150 kilograms that I mentioned—I am talking about, if you take the modes they talk about—they talk about housekeeping, alert, and then burst—how much power you have to have to maintain each one of those systems in SDI.

And you are talking about hundreds of megawatts for that few hundred seconds when you are going to need it. And you are talking about thousands and thousands of pounds of highly enriched uranium to do that.

Now, I do not know what your position on SDI is, but let me ask you this. Given the possibilities that I mentioned a moment ago about the Soviet Rorsat that is coming down, do you think this is a very good idea or not?

Dr. SCHLESINGER. Well, I think that it is clearly not a good idea at this point. We do not have anything like a strategic defense option. As we look out a decade and a half, we will have to examine the cost effectiveness, the survivability of any hypothetical space-based strategic defense system.

What we are still talking about is ground-based, and that is something well down the line. As your question implies, I certainly would prefer to be able to avoid putting a reactor in space, and I would think that those who are developing the system, the strategic defense system, would prefer to have the—would not prefer to have the reliability, overall reliability of the system, depend upon the reliability of individual nuclear reactors on space platforms.

Senator BUMPERS. I could not agree more, and that is what SDIO will tell you right now if you ask them: That is not something that we are seriously considering right now; these would be ground-based.

And yet, the American Physical Society group who studied directed energy weapons and a host of other people who have looked

at it say that ultimately the chances of SDI really working without the considerable power in space is not very promising.

Dr. SCHLESINGER. I think that the most—these prospects all have a long, long way to go. But the most interesting prospect with regard to laser weapons, I believe, is the ground-based laser.

Senator BUMPERS. Let me just close, Dr. Schlesinger, by saying that we are in sort of a predicament here with our budget constraints, needing, as you say, to give incentives to exploration, even though production of oil in this country is going to continue to decline under the best scenario you can develop.

You might see a small blip if ANWR proves to be very productive, but that is about it.

I will tell you an interesting story. This old man in Arkansas with about an eighth grade education, but a lot of common sense. I remember when Ronald Reagan was going around saying, we are going to double defense spending and cut your taxes 30 percent and balance the budget. The old man said: What a great idea; I wonder why nobody ever thought of that before?

Thank you, Mr. Chairman.

Dr. SCHLESINGER. Well, that is voodoo, Senator.

The CHAIRMAN. Senator Domenici, Senator Wirth has to go to a conference.

Senator WIRTH. I thank the Senator from New Mexico. Thank you, Mr. Chairman.

Dr. Schlesinger, we are lucky to have you and thank you very much for being here. We really appreciate your great counsel and help.

In your opening comments, you call for again a national energy policy, and the refrain was threefold. I can remember two elements before, the trade issue and our national security interest.

And you touched upon a third one briefly this morning and that was the greenhouse effect. I was wondering if you might sketch for us, one, how severe you think the greenhouse issue is, and if it is, as I gather from your opening comments you thought it really is severe, then, one, what should we be doing in the Congress?

And second, how do we get the issue of the greenhouse effect up in terms of get it up in the lights, get it up in terms of priority, get people to understand the severity of the greenhouse issue?

Dr. SCHLESINGER. Senator, as I mentioned earlier, I think that the scientific evidence with respect to the greenhouse effect becomes increasingly compelling. I think that it is a chronic and growing problem. It is not severe as of today, although we have seen that the temperature of the earth has risen and that prospectively we will see a melting off of the ice in Greenland and Antarctica which will raise the surface of the oceans.

That will be less of a problem, if I may say so, in Colorado, Senator, than it will be in Louisiana, or southern Louisiana in particular.

But we will have to adjust. It will have major impact on climate, and nobody knows whether the temperate zones, including the United States, Canada, Europe, the Soviet Union, which are now the great grain producing areas of the world, will not be adversely affected.

We are going to have to make gradual adjustments over time. So in the energy area, it would seem to me that as the demand for energy grows worldwide, as it must—as we see the world population rise from two billion, now five billion, continuing to rise, energy demand will rise.

That augmentation of demand it seems to me in the future ought to be increasingly nuclear, simply because nuclear power is a form of energy production that does not involve any air pollution, and therefore, one restrains the addition of carbon dioxide and other gases in the atmosphere that would intensify the greenhouse effect.

It is a problem that will come over decades, rather than one that is immediate. But we need to have decades to adjust our thinking.

Senator WIRTH. Just in brief response to that, I am not sure that the decades is accurate. I think that it may be here much more rapidly if you look at——

Dr. SCHLESINGER. Oh, we have already seen——

Senator WIRTH. We have very severe climate change problems going on in this country right now. And you know, that impacts more than just on the melting as well. I mean, we could have a lot of empty dams in the West, you know, as the temperate zone moves further north and we end up being a desert and so on.

Dr. SCHLESINGER. I do not want to understate the problem. We have seen a rise of about two degrees in the last century of the earth's temperature. It is having its effect.

When I talked about decades, I think that that was more along the line of what I said earlier, about we do not recognize the handwriting on the wall until our backs are up against it. And it will take us decades to adjust. Even though we have a problem now, it will become more intense in the decades ahead.

Senator WIRTH. But it seems to me that it is incumbent upon us in the Congress to try to do a couple of things: one, to do everything that we can to legitimize the fact that the scientific evidence is out there and that this is not something that a few tree-huggers behind a couple of rocks have been talking about, but is a very, very severe problem and that we ought to be talking about that;

Second, that we ought to be looking not only at the nuclear side, but a variety of other parts of this. It impresses me that we ought to be looking at, where does the greenhouse effect come from? Largely, as you suggest, fossil fuels and carbon; and what do we do on that front to try to diminish, rather than increase, the amount of carbon going into the atmosphere.

And that goes to various energy strategies, as well as to various rain forests, various forestation/deforestation strategies; that there is an overall package of this that we have to be thinking about.

It is very difficult to do. It is going to cause some incredible disruptions and a lot of alienation, and I am sure a lot of people are going to be unhappy, you know, with those kinds of changes.

But I would think that the priority of that has got to move up our agenda very significantly.

Dr. SCHLESINGER. I agree, Senator. Part of our problem, of course, is that those problems that cause inconvenience are those problems that we prefer not to recognize and usually can defer recognition for a long time.

Senator WIRTH. Well, you have always been wonderful at making us face those problems, and I appreciate your help this morning, and it will add a little bit more momentum.

I thank again the Senator from New Mexico for letting me squeeze in again.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Wirth.

Senator Domenici.

Senator DOMENICI. Thank you very much, Mr. Chairman.

Secretary Schlesinger, let me ask you if you agree with this proposition. I was riding from San Jose to Albuquerque with someone I think you know, and if you do not you have always known their predecessor, the director of the Sandia National Laboratories, Dr. Irwin Welber. It is a one hour drive.

And I think he had been waiting for an opportunity to present a scenario to me, and he said: Pete, I want you to listen carefully. I want to make a point with you and I do not know how to do it other than, you are always talking about the Japanese and so I would like to talk about them for a minute.

He said, if the Japanese government and businesses and policymakers were given 25 years to control and develop the natural energy resources of these United States, they would not only establish a policy of energy independence, but they would establish a policy that within 25 years they would be the world's largest exporter of energy.

Now, that sort of shocked me, especially since I looked at the balance of trade for a hearing we had just to bring it current, and I think it is now at about 44.5, moving up on $50 billion a year for just petroleum products, just oil.

Without going into some of the suggestions made by you here today and by him there that day in the car, do you agree essentially with that premise, that we do have the kind of—assuming maximum conservation and the right kind of policies, that these United States have at least the opportunity within a reasonable period of time of being energy independent, and if we really were committed we might indeed be a major exporter of energy?

Dr. SCHLESINGER. Let me try and sort out that question if I may, Senator, starting with the Japanese. I think that the likelihood that they would achieve energy independence and would not be dependent upon imports is 100 percent. That is, it follows as the night the day that they would avoid becoming dependent on foreign sources of supply.

Senator DOMENICI. If they had our resources?

Dr. SCHLESINGER. If they had our resources.

Secondly, they might indeed become a major energy exporter. I think that that is—that might be a reflection of the Japanese compulsion to export more than rational economic policy. But they might indeed go in that direction.

My concern, Senator, continues to be the vulnerability of the United States, as I am sure yours is. We do not need to be utterly energy independent to achieve that. But we certainly ought not to be dependent for 60 percent of our oil, as we will be toward the turn of the century, on the Persian Gulf, so far away.

If we could hold our dependence on critical products like oil to 25, 30 percent, I think that we will hold our vulnerabilities down, and we ought to strive for that. It is easier for Japan Incorporated to achieve goals of that sort than the United States, with the great dispersion of power, which is the advantage of freedom but also the cost of freedom.

Senator DOMENICI. Now, Mr. Secretary, clearly I need not state on this record my concurrence with you with reference to nuclear energy. I do believe this generation, going back eight or ten years and for the next 15, as I see it, absent a realization that the ozone crisis is real and that we are motivated by that as being a real current problem, absent that, I do not see this country moving dramatically in nuclear energy just because we have that terrible fear of the genie and radiation, and we just cannot seem to sell it. I congratulate you for making the point again that we ought to get on with it.

But having said that, it seems to me that some things that we could do that we are not doing are pretty fundamental and simple. We have a huge resource called coal, and we take a huge resource still in ground called the unrecovered oil, that even with current secondary and tertiary processes those who look at it say clearly they are rather fantastic quantities that we are not getting out of the ground.

I am told by that same person in that one hour trip that—and I have not shared it with this Committee, and I am hoping to try to get him to do something. This particular scientist says we are doing little or nothing to put the best scientists in the United States in looking at two simple propositions:

One, what are the essential and basic physical and geological qualities of coal? We think we know, but, says he, we do not. We have tried synthetic fuel, but essentially that was nothing more than adapting and modernizing the technology that the Germans had during the Second World War and the South Africans had in terms of producing from coal a liquefied type product that can be used in the transportation and the feeding of industry.

So he says, why in the world would we not do that?

Secondly, he says there is plenty of talent around to look at mother earth as it pertains to oil and gas and find out some essentials that might indeed reveal ways and means of getting 20, 30, 40 percent more crude oil out of the ground in new and different ways, that might indeed be marketable.

I put this proposition before you only because it seems to me that sometimes we miss the forest for the trees. We talk about fusion, and of course we ought to be doing that. That may be humankind's ultimate salvation in terms of energy.

But for now, am I right that some of these basic things that this very dedicated person commented on could be done, ought to be done? What are your observations about them?

Dr. SCHLESINGER. Well, Senator, I fully agree with you and your interlocutor. There are these areas that demand further exploration.

In addition to better understanding coal and how to use it, how to use it cleanly, and a higher recovery rate for oil, there is geopressured methane which is down, notably in the State of Lou-

isiana that the Chairman represents. That is a very substantial resource if we can find the technology to develop it.

We could not do it in two or three years. But if we are looking at 20 and 30 years, we ought to be working on that technology.

There is also oil shale that we can do much more. And these are areas in which we ought to be vigorously developing technologies.

Senator Ford, may I augment my previous answer to you with regard to the proper role of the government with these comments as well. The earlier comment was confined to reactors.

Senator DOMENICI. I came here wanting to talk about the space power program. I understand the hearing was on that subject also. But I just want to ask you one question with reference to it and make one observation.

It is my understanding, by way of observation, that whatever America's space power program that involves nuclear reactors as a source of power, whatever it is, it is my understanding that the unequivocal criteria for development is that we cannot have the kind of situation that the Russians have.

It will be developed such that on the way up, if something happens, you cannot have live radioactive material coming back to earth. And I understand the specs require that if it comes down from outer space, it cannot hit the earth with any of the radioactivity that is being spoken of with reference to the Soviets.

Is that your understanding?

Dr. SCHLESINGER. Yes, sir.

Senator DOMENICI. And we will not do it unless those criteria are met, as I understand it, any of the three that are being developed, that we are wasting a lot of money on because we cannot make a decision. They all have that criteria, is that not right?

Dr. SCHLESINGER. That is my understanding, yes, sir.

Senator DOMENICI. Now, Mr. Secretary, with reference to that, we have the DIPS program, which is the low power reactor, about ten kilowatts; we have the SP100, the medium powered reactor; and we have the multimegawatt, a high powered reactor.

Now, some of us have been concerned since about 1981 that between NASA and DOE there is a great deal of confusion as to the mission. I still believe that exists. I think we are asking the Department of Energy to proceed on three fronts with not enough money to do any of them.

We sort of have eyes that are much bigger than our stomach. It seems to me we ought to decide on one of the three and have it proceed with sufficient resources. I believe it ought to be the SP100, but it does not matter.

Do you agree that we are making little or no headway because of the confusion and spending not enough money on three different approaches?

Dr. SCHLESINGER. I am not that familiar with the program to say that we are making little headway. But I agree with your point on prioritization, Senator. I think that one of the ways that we are going to have to react to the budget pressures, which you know as well as anybody in the Senate from your experience with the Budget Committee, is that we are going to have to slow down our new starts.

It is going to be true in the Department of Defense. It is going to be true outside of the Department of Defense. And that one ought not to put in enough money to keep all programs alive and going. One ought to be more selective, so that one can complete programs in a reasonably timely manner.

Senator DOMENICI. Thank you very much, Mr. Chairman. Thank you, Mr. Secretary.

The CHAIRMAN. Dr. Schlesinger, thank you very much for your testimony. We have been instructed, edified, and entertained all at once, and we appreciate that and hope that we will have you back from time to time as we find the quick and easy solutions to this energy crisis.

Dr. SCHLESINGER. Thank you, Senator. It is a pleasure to be with you.

The CHAIRMAN. Next we want to welcome the Honorable Ted Garrish, Assistant Secretary for Nuclear Energy Programs at the Department of Energy.

STATEMENT OF THEODORE J. GARRISH, ASSISTANT SECRETARY FOR NUCLEAR ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY: DEL BUNCH, PRINCIPAL DEPUTY ASSISTANT SECRETARY FOR NUCLEAR ENERGY

Mr. GARRISH. Thank you very much, Mr. Chairman, for the opportunity to appear today. I am accompanied today by Mr. Del Bunch, who is my deputy. He is also prepared to answer questions from the subcommittee.

I understand time is short, so I offer my written statement for the record, and I could just summarize some of the principal points in the testimony.

First, Dr. Schlesinger has very clearly stated the need for nuclear energy in the future. Without nuclear energy, an additional seven million barrels of oil per day would be required, and it would have a very significant impact on oil prices and our strategic dependence on imported oil around the world.

Nuclear power is important for a balanced, diversified, and secure energy supply. About 18 percent of our electricity comes from nuclear energy, and members of this committee know all too well that we will be needing new generating capacity in the mid-1990's to replace our old plants, and this is a very important option which needs to be continued.

A number of activities are currently being undertaken that are essential to the viability of this option. Let me quickly just mention a few of those.

First is the high level nuclear waste program, and Congress has made very, very good progress on that under the leadership of this Committee. That is an activity which will require continued work by the Department and possibly continued legislation in the future.

Secondly, the Price-Anderson bill has moved along in both houses, and we have made good progress on that. Those are very important steps.

And finally, there has been considerable interest over the years in improving the licensing process. Numerous proposals have been made and it continues to be needed. This committee has considered

those questions in the past, and there are current proposals now being considered.

Finally, we are continuing to work on the design and development of improved reactors, and that program offers some very important benefits for the future of nuclear power. Some of those programs are the items that we need to discuss this morning.

In the immediate future, our civilian reactor development program is the light water reactor. Over $200 million has already been invested in these reactors. The most likely next plant order will feature that technology. We have a program designed to determine what the industry requirements for the next few years would be for that reactor and to begin the process of certification with the licensing authorities.

We need to look for achievable improvements in our technology and to smooth out the licensing process. That is one of the elements of our program that is extremely important.

Into the future, we are exploring passive safety systems in an effort to develop a future class of reactors that will assure greater safety margins. Our efforts are focused on developing the advanced reactor technologies, the liquid metal cooled reactors and the modular high temperature gas reactor.

In order for these reactors to meet the social and economic challenges of our licensing process, we must determine as a matter of first priority a number of issues which we think need to be addressed.

The first is whether or not passive safety can in fact be achieved, whether or not it is a reality. That is one of the issues that we need to look at first.

We need to determine whether an updated licensing process for these reactors would alleviate the public concern over their safety. We need to determine whether that can be completed in a cost-efficient and time-efficient manner; and whether the advanced reactor system can develop processes for fuel and waste which would help overcome public concerns about those particular processes; and whether or not inexpensive fuel with the high breeding potential can in fact be developed.

Our research is directed at trying to answer those points and those questions. DOE is committed to answering these questions and to dealing with the public uncertainty that each of those questions have for the future.

There has been a considerable discussion on the question of legislation and what legislation might be appropriate to help encourage this process, and let me turn to that in a minute, in more detail.

First, we do strongly believe that we need to continue to deal with the obstacles to the licensing process, regardless of what other technological work is being done.

Those are very important first steps before the private sector would be able to determine that it wants to commit the resources to make the advanced reactors a reality. We need to deal with the public perception of the safety of nuclear power. We need to discuss that with the regulatory bodies concerned.

The process of evaluating costs and determining allowable return on investments in nuclear power also needs to become more reliable and predictable.

We believe that in the process of looking at legislation there are a number of key factors which are important for our program, and we would encourage the Congress along the same lines.

The first is that we believe the program and the approach should be technologically neutral at the onset. We believe it is crucial to not prejudge which technology is the best, or to commit ourselves to a course that precludes a thorough search for the best design.

A commitment needs to be made to ensure that research and development activities keep pace with the desired project schedule. Once we determine what the project is and what the size is, we believe it is important that the Administration commit itself to that total project and keep its commitments and keep the process moving.

In addition, an effort must be made to guard against major cost overruns, a problem which can arise easily under an accelerated development schedule. The various steps in the process should be coordinated to assure that the project's momentum does not outpace the necessary resolution of the problems that it runs into along the way.

Furthermore, it is important to ensure that the ultimate design is one for which there will be a market. A program must produce a design in which the industry would be willing to invest.

At the Department, we share the committee's interest in the development and deployment of safe, well-tested, economic nuclear power sources, and we are prepared to work with the committee on trying to develop a program or legislation to best achieve the results that I think are in the best interests of the country and our energy future.

[The prepared statement of Mr. Garrish follows:]

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STATEMENT OF THEODORE J. GARRISH
ASSISTANT SECRETARY FOR NUCLEAR ENERGY
U.S. DEPARTMENT OF ENERGY
BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
U.S. SENATE

MAY 24, 1988

Mr. Chairman, I am pleased to have this opportunity to discuss the Department of Energy's (DOE's) program and fiscal year 1989 budget request for its civilian reactor research and development (R&D) program, which includes space and defense-related power systems development activities.

Detailed funding tables are included in the discussion of each major program.

OVERVIEW

Nuclear energy plays a critical role in maintaining a secure and stable energy supply. Worldwide consumption of oil is about 59 million barrels of oil per day. Without nuclear energy, an additional 7 million barrels per day would be required to replace the electricity generated by using uranium as its fuel source. This would have a significant impact on oil prices and upon our strategic dependence on imported oil.

Nuclear power plays a key role in assuring a balanced, diversified, and secure energy supply for America. Over 100 commercial nuclear powerplants generate nearly 18 percent of the United States' electricity supply. Based on conservative projections, there will be a need for new electrical

generating capacity by the mid-1990's to replace old plants and to meet the increased demands of our expanding population and economy. Utilities should be able to consider building nuclear plants to meet a portion of this new capacity, yet the nuclear power option faces numerous, interrelated institutional problems that make its future use in the U.S. uncertain.

Nuclear energy is at a critical point in its development. A national program is needed that will effectively address these institutional problems to ensure the continued development and deployment of nuclear power sources. Although nearly 400 nuclear plants have been constructed worldwide, we in the United States need to resolve those issues that challenge the future use of nuclear power as a key contributor to our country's energy security, stability, and strength.

First, we must put in place facilities that will safely store nuclear waste. Congress, through recent amendments to the Nuclear Waste Policy Act, has provided the framework within which the Department can proceed to select sites and construct facilities that can safely dispose of high-level radioactive waste. The Low-Level Radioactive Waste Policy Amendments Act of 1985 provides a fair and practical framework that will lead to new low-level waste disposal capacity developed by individual States and regions with limited Federal assistance.

Second, Congress must extend the Price-Anderson nuclear insurance and contractor indemnification system. Price-Anderson renewal is an

affirmation of our joint commitment to the future of nuclear power. Without this mechanism to ensure that the public would be fully compensated for damages arising from a nuclear-related incident, no new nuclear plants will be ordered. Moreover, we will find it increasingly difficult to attract and retain qualified industrial partners to operate the Government's unique nuclear research and production facilities.

Third, domestic fuel cycle activities, including the uranium enrichment enterprise, must have an opportunity to compete in world markets as an essential part of assuring a secure domestic fuel supply.

Finally, the elimination of uncertainty in costs and schedules is an essential prerequisite to new nuclear plant orders. Revisions to State economic regulation and the process by which commercial nuclear facilities are licensed must be made if we are to have nuclear power available to meet a portion of a needed expansion of our generating capacity.

We believe DOE programs provide an important contribution toward resolving these institutional issues and provide for the long-term development and deployment of nuclear power sources. The goals of DOE-sponsored reactor R&D programs are:

- to complement industry-led efforts to secure nuclear power as an attractive option for new electricity capacity in the 1990's;
- to conduct R&D on advanced reactor systems that show the potential for significant breakthroughs in economics or safety: and,
- to utilize nuclear technology to meet NASA and DOD power requirements to enable future civilian and defense-related missions.

The funding request for Nuclear Energy R&D programs is contained in the following table.

Program Element	Budget Authority ----(S in Millions)---- FY 1988 Appropriation	FY 1989 Request
Nuclear Energy R&D		
Light Water Reactors	$ 32.0	$ 26.8
Advanced Reactor R&D	92.6	61.2
Space/Defense Power Systems	75.2	117.0
Advanced Nuclear Systems	21.0	27.7
Facilities	117.7	110.7
Program Direction	8.5	8.5
Total	$ 347.0	$ 351.7

LIGHT WATER REACTORS

The Nation's economic and national security requires a diversified energy supply base built upon adequate, domestic resources that are relatively free from international pressures. Nuclear energy is a vital component of the national energy supply and is essential to meet current and future national energy demands.

The Light Water Reactors (LWRs) program is one component of the Civilian Reactor Development Program. The mission of the Civilian Reactor Development Program is to support the national energy supply policy by developing and implementing programs to ensure that nuclear energy remains a safe, economically competitive and environmentally acceptable option that continues to contribute to national energy stability, security and strength.

The fundamental goals that must be achieved to fulfill the mission of the civilian reactor development program are:

- to provide an effective and predictable regulatory and institutional environment that enables nuclear power projects to compete freely in the marketplace;
- to support and facilitate industry-led technology efforts to revitalize the LWR option for the U.S. and to ensure its long-term availability as a vital component of the national energy supply system;
- to explore the feasibility and practicability of advanced nuclear reactor systems with the potential for breakthroughs in economics, safety, licensability, and waste management options; and,
- to support long-term national interests by conducting cooperative international nuclear R&D projects that further U.S. nonproliferation objectives strengthening our position in international commerce, involving key universities in nuclear R&D utilizing DOE facilities and providing options to meet longer-term needs to extend uranium resources.

The last two goals are addressed by the Advanced Reactor R&D Program, which is discussed in a later section.

The LWR program is focused primarily on the first two goals. It provides visible national support and complementary research and development to foster successful industry-led efforts to ensure the availability of the LWR option.

The objectives of the LWR program are to:

- encourage development of improved designs and support Nuclear Regulatory Commission (NRC) and utility certification of such designs for use as standardized plants for the 1990's;
- utilize the results from severe accident, source term, and safety technology programs to assist in the removal of institutional barriers

currently inhibiting the introduction of advanced LWR's in the U.S. marketplace;

- o support industry initiatives through complementary R&D to extend the life of the Nation's existing nuclear powerplants; and,
- o provide technical support and analyses of domestic and foreign efforts to improve the opportunities for the LWR option.

Success in advancing the LWR option is essential to meet projected power demands of the 1990s.

The major focus of the program is to develop and obtain utility and NRC certification of a much more attractive version of LWR technology, the Advanced Light Water Reactor (ALWR), suitable for deployment in the years ahead. This first program element augments industry reactor design programs and is oriented towards designs which can be deployed without the need for a demonstration plant. It includes support for certification, by the NRC, of an advanced 1,300 megawatt-class pressurized water reactor (PWR) and an advanced boiling water reactor (BWR) by 1991; development and key features proof testing of innovative mid-sized (600 megawatts of electric power, or MWe) BWR and PWR plant concepts; and supporting activities to ensure that plants are designed for constructibility, and later incorporation of advances in the technology. These activities fulfill the Department's commitments to complement the Electric Power Research Institute (EPRI)/industry work on advanced LWR's.

The second program element--Current and Advanced Light Water Reactor Safety and Licensing Support--provides technology support to the ALWR program. It applies the results of the severe accident technology programs to the

implementation of the Severe Accident Policy Statement for ALWRs to prevent severe accident issues from forestalling acceptance of ALWRs. It develops technology to support the extension of nuclear powerplant life beyond the current 40-year licensing period, and provides the basis for achieving the ALWR design life of 60 years. It further explores solutions to other institutional impediments to the deployment of nuclear powerplants.

Advanced Light Water Reactor Program

U.S. utilities have, for several years, been leading an industry-wide effort to establish a technical foundation for the design of the next generation of light water reactors in the United States. This utility initiative has been effected via a major technical program managed by EPRI. The Department's ALWR Program is closely coordinated with the extensive related advanced light water reactor work sponsored by EPRI. The program is growing in national and international prominence and it now involves participation on the part of several Far East utility companies, with prospects of one or more European partners as well.

This ALWR Program has been established to meet the need in the U.S. for a new generation of light water reactor plants. Despite the political and institutional factors which today discourage the continued deployment of nuclear power sources in the U.S., nuclear energy remains an important part of our nation's present and future power supply.

Three fundamental standards must be met before the ALWR can be considered a viable candidate for U.S. utility investment. First, it must be an

excellent powerplant in all respects. This includes safety, foremost, but must also embrace all of the criteria by which real powerplants are measured, including reliability, maintainability, and compatibility with the environment. Secondly, it must be economically attractive in comparison to its alternative fossil-fired units. Finally, and of particular importance for nuclear plants, the ALWR must provide very high protection of utility investment, in terms of predictable construction costs and schedule, assured licensability, predictable operating and maintenance costs, and very low risk of severe accident. In short, the investor must have extremely high confidence that the high capital cost of a nuclear plant is warranted.

The Department's ALWR program includes three key tasks:

- o support for the EPRI/industry program of defining technical requirements for ALWRs;
- o support for certification of two ALWR standard plant designs to demonstrate resolution of technical issues and the efficacy of the standard plant licensing process; and,
- o performance of a technology program to develop greatly simplified mid-sized (about 600 MWe) LWRs that apply predominantly passive safety features, and assuming favorable results, to support licensing of such standard plant designs.

The first task involves support for industry generation of detailed requirements for future LWRs. There are over 100 operating nuclear plants in the United States. These plants constitute an extraordinary experience base from which compelling conclusions can be drawn regarding both desirable and undesirable design features. Notwithstanding plant-to-plant variations, the overall performance of U.S. nuclear plants has been good.

Specific regulatory guidelines, plant operator training methods, and specific hardware designs have evolved based on these existing reactor systems. For all these reasons, a logical and high-success approach for the ALWR Program is to examine carefully this existing technical basis and to develop an ALWR design which is an evolutionary improvement or refinement of the existing design base. Industry appropriately has the lead in this effort.

EPRI's efforts pursue this course in developing a set of specific and detailed design requirements for an evolutionary ALWR, for both BWR and PWR designs. In each case the design concepts, systems, and hardware specified are conventional in nature, but they employ the ALWR principles outlined above. For example, a PWR designed to the standards established for the evolutionary ALWR would utilize a conventionally configured reactor coolant system, but with substantially improved reactor coolant pump seal design, steam generators having greater secondary side-water inventory, and a pressurizer designed to accommodate a full post-scram pressure and temperature transient without requiring pilot-operated relief valve actuation. The BWR version of the evolutionary ALWR would employ internal recirculation pumps and improved control rod drive design.

The second task of the Department's ALWR program includes support for safety reviews by the NRC of two large (1,250 to 1,350 electrical megawatts, or MWe) standard plant designs--the General Electric (GE) Advanced Boiling Water Reactor (ABWR) design, developed in collaboration with the Japanese, and the Combustion Engineering (CE) "System 80+"

Advanced Pressurized Water Reactor (APWR) design, using the "System 80" Palo Verde design as its basis. Good progress was made last year in establishing the NRC review process, coordinating with the EPRI/utility industry requirements and criteria, and in submitting the initial chapters of the Standard Safety Analysis Reports (SSARs) to the NRC for review. These SSAR submittals, and related safety analyses, will continue throughout FY 1988. In FY 1989, additional required risk assessments and safety evaluations will be prepared, and revisions to the safety reports and evaluations as needed to resolve NRC comments will be submitted. Based on favorable review, these plant designs are expected to be certified by the NRC in late 1991.

In the third task area, technology development support is being provided for two mid-size (600 MWe) plant concepts--a BWR and a PWR design. These plants offer the opportunity to incorporate further, highly desirable, evolutionary changes to LWRs. Designs are being developed which will not only build on the extensive experience base from the last three decades of reactor operation, but will also take advantage of potential simplifications and innovations in design and construction that are unique to the smaller power rating. These include the application of more-passive systems and the increased use of modularization to improve construction.

The passive LWR design option is less developed but very attractive over the long term. In concept, the ALWR passive plant is one which employs primarily passive means (such as gravity or natural circulation) to remove decay heat and provide emergency core cooling to prevent core damage, as

well as to contain fission product activity even in the unlikely event of a core damaging accident.

The incentives for developing a passive plant concept are substantial:

- The passive plant protection systems envisioned are vastly simpler in concept than the complex safety systems utilized in existing plants. Therefore, the passive plant offers far greater opportunity than the evolutionary plant to effect wholesale simplification (in the form of reduction of many valves, pumps, takes, instruments, etc.) with attendant improvement in construction cost and schedule, plant operability, and maintainability.
- By eliminating reliance on active components and human intervention, the passive plant has potential to offer greater safety under a wider range of upset conditions and internal and external plant threats such as loss of all electrical power.
- The passive plant may be more easily licensable than existing plants because of the substantially reduced space of safety related equipment.
- The passive plant offers potential for renewed public and governmental confidence in that it represents a significant improvement over current practice.

A plant size of about 600 MWe may prove to be an advantage in its own right since it may fit more easily into the capacity planning schemes of most U.S. utilities. Also, such plant sizes offer a potential for shorter construction time, more extensive modularization of plant equipment, and other factors that can improve overall plant economics.

Safety and Licensing Support of Current and Advanced LWR'S

The three elements of this part of the program dealing with plant lifetime, severe accidents, and institutional matters support not only ALWRs but also bear significantly on extension and preservation of the current national energy resource represented by today's LWRs.

The 100-plus nuclear powerplants now in commercial operation are a large, untapped resource of energy when one considers that their current license life of 40 years is not based on technical restrictions. An additional 20 years of operating life, representing nearly 88,000 megawatts of capacity, is potentially available and can directly offset some of the need for new or replacement generating units. In order to preserve this resource, the criteria and technical bases for replacement, refurbishment, or continued use of components and systems, are needed by both utilities and regulators. In addition, the procedural requirements to be used by regulators for license extension reviews must be developed and agreed upon. This ranges from questions on compliance with regulations issued during the plant operating life to issues on cost recovery allowances by economic regulators. In FY 1988, the development of the technical base for one of the key components, the reactor containment, will be pursued. Questions regarding electrical cable and reactor vessel life are also being addressed. In FY 1989, support for a lead plant, including safety analyses and application of developed criteria, will be initiated with a selected utility contractor on a cost-shared basis for preparation of the initial application for license renewal. This is a key step toward the final objective of getting the lead plant license renewal in 1993.

In the severe accident area, one aspect of the program is to apply expertise gained from the severe accident technology program to the identification of potential design improvements for future plants that may result from the resolution of severe accident issues. In cooperation with the utility ALWR Steering Committee, the DOE program has provided input on safety requirements and supporting bases for a Utility Requirements Document. The key chapter on safety and severe accidents in this document has been submitted to NRC and interactions with NRC will take place during FY 1988. In FY 1989, discussions with the NRC on the acceptability of these requirements will be completed. As part of the support the severe accident program is providing to the ALWR certification program, topics papers on key severe accident issues are being prepared. These papers represent suggestions for closing severe accident issues for the ALWR. Two sets have already been provided to the NRC by CE officials and the additional four topic sets will be provided in FY 1988. Interactions with the NRC staff on these severe accident issues, initiated in FY 1988, should be completed during FY 1989. Documentation of these results will be incorporated in specific Final Design Approvals from the NRC for the ALWR designs, as well as in revised NRC rules, regulations, and guides. A multiple benefit of this issue resolution process will be the application of the conclusions to current operating plants.

Another aspect of severe accident investigations deals with understanding reactor concepts from other countries. The impact of an accident like Chernobyl makes it clear that we must understand the behavior--both

strengths and vulnerabilities--of such designs and to coordinate feedback from these investigations into the design process in all countries.

In FY 1987, the loss-of-fluid test (LOFT) reactor was deactivated as the Organization for Economic and Cooperative Development (OECD) LOFT consortium proceeded with preparations to perform a post-test irradiation examination of the damaged test fuel. These examinations will be completed in FY 1989.

Three Mile Island

No additional funding for Three Mile Island (TMI) activities is being requested in FY 1989 because DOE will complete its R&D program with funds appropriated for FY 1988.

The GPU Nuclear Corporation (GPU Nuclear) expects to complete defueling of the core debris by the end of 1988 and complete shipment of the core debris in 1989. GPU Nuclear also expects to complete the recovery program and place the plant in a safe, monitored condition during 1989.

Shipment of the core debris is a joint effort shared by GPU Nuclear and DOE. Currently, GPU Nuclear tasks for debris removal and loading into canisters control the schedule. DOE will maintain shipping on a schedule consistent with fuel availability. Approximately one-half of the 300,000 pounds of core debris material had been shipped to the Department's Idaho National Engineering Laboratory (INEL) by the end of 1987.

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The TMI Unit 2 Accident Evaluation Program made progress in the areas of sample examination and accident evaluation during FY 1987. The program issued a revised accident scenario that incorporated observations from core bores that penetrated through the rubble to the bottom of the core. In some cases, the bore tool extended into the lower plenum within 10 inches of the bottom head. Additional information on fission product distribution and more detail on the condition of the lower core has been obtained as debris is removed and the lower regions of the vessel are exposed to allow direct examination. A large number of samples of core debris were shipped to participating OECD/Committee for the Safety of Nuclear Installations (CSNI) members for extensive examinations. These results will be coordinated and integrated with the examinations being carried out by the Department and the NRC. During FY 1988, a final revised accident scenario incorporating the results from the CSNI program will be prepared. This will include the observations made during the lower vessel defueling and DOE sample examinations.

ADVANCED REACTOR R&D

For FY 1989, the Department is requesting $171.9 million for advanced reactor research and development and nuclear energy facilities support. Advanced nuclear reactor power systems offer the potential for significant breakthroughs in economics, safety, licensability, and waste management options compared to LWR systems. The principal vehicle for achieving these breakthroughs is the Integral Fast Reactor (IFR) concept, which uses a metal-fueled, liquid metal-cooled system.

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The goal of the Department's Advanced Reactor R&D program is to develop and demonstrate liquid metal-cooled reactor (LMR) and high-temperature gas-cooled reactor (HTGR) systems that meet evolving market needs. The introduction into the marketplace of new reactor systems developed through R&D on advanced technology depends on the attractiveness of the technology to utilities and the public and on the need for additional generating capacity. It is important to verify that these alternative systems do, in fact, provide the promised breakthroughs; that modular plants can overcome the economies of scale enjoyed by large plants; and that these designs are at least as, if not more, licensable than competing LWR designs. Current licensing reviews are of paramount importance in pursuing these objectives. The program is organized into two major areas--first, LMR design, fuel cycle, and technology R&D (which are supported by essential test facilities) and, second, modular HTGR design and technology R&D.

Significant breakthroughs in economics, safety, licensing and waste management options are important objectives of the Department's program. The Department believes that these objectives can be achieved through new reactor designs and exploration of advanced fuel cycle options. The promise that these new systems hold is clear--modular, standardized designs will lead to lower costs; factory fabrication will lead to stabilized lower construction costs and improved quality assurance; the capability of increasing capacity by combining standard modules will meet utility load growth and financial constraints; advanced control systems will lead to improved reliability and operator response; and the use of passive safety systems will assure the termination of the chain reaction process and the

return of the reactor to a safe, stable state under a wide-range of plant conditions. The intent of the design development activity, including NRC and utility reviews, is to determine whether inherent safety features and opportunities for shop fabrication of both LMR and HTGR systems will lead to an attractive product as compared to future LWRs and coal plants.

Advanced Liquid Metal Reactor

The Department is giving priority support to the development of the IFR concept based upon R&D work completed to date that shows the potential for significant breakthroughs in improved economics, passive safety, licensability and waste management options. This metal-fueled, liquid metal-cooled system has the additional potential for spin-off applications for defense missions and as an actinide burner which could greatly simplify nuclear waste management.

Specifically, the Department will focus metal fuel development R&D in FY 1989 on safety tests in support of key design and licensing requirements, fuel fabrication and testing to demonstrate performance and full scale fabrication capability, and demonstrating the metal fuel cycle including reprocessing and an advanced waste treatment process.

While ternary metal fuel is the current reference design, efforts on the LMR oxide fuel cycle will continue in FY 1989 as part of a cooperative R&D effort with the Japanese. In support of this program, in FY 1989 the Department will continue the Core Demonstration Experiment with a large-scale test of irradiated mixed-oxide fuel with planned completion in 1992

and complete PFR/TREAT tests in cooperation with the United Kingdom. The collaborative reprocessing program with Japan will continue; key elements of this collaborative effort include disassembly system design, dissolver design, and related activities. Technology development verifies design features, safety margins, and potential cost savings of advanced reactor systems. Performance expectations will need to be confirmed for new plant features, control systems, components, and materials.

Modular High Temperature Gas Reactor

The FY 1989 budget request includes $7.7 million for modular HTGR development. In FY 1989, the Department's efforts will focus on maintaining a base technology to support future applications of the HTGR and to allow continued collaboration with international programs where advanced designs and supporting R&D are being actively pursued. Preliminary design activities initiated in the United States in FY 1988--along with continuation of existing international agreements with Japan, the Federal Republic of Germany (FRG), France, and Switzerland--will provide a basis for this U.S. collaboration.

FACILITIES

DOE's test facilities are among the most advanced and sophisticated in the world and are essential to the continued development of advanced reactors, fuels, components, and materials. The major facilities involved in the Department's advanced reactor R&D efforts are located at three sites: Argonne National Laboratory-West (ANL-W) in Idaho; the Energy Technology

Engineering Center (ETEC) in California; and the Westinghouse Hanford Company (WHC) in Washington. Funding for the operation and maintenance of these facilities has been reduced substantially in recent years. Over the last 7 years the facilities program budget has been reduced by approximately 50 percent, due in part to improved operational efficiency and in part to completion of construction work in progress. Any facilities that do not directly support reactor development programs have been shut down or converted to other uses.

Although DOE has been successful in reducing its funding requirements for facilities, safety and quality of operation continue to be of the highest priority. The FY 1989 budget request provides for the continued safe and effective operation of its nuclear test facilities.

To reduce further the funding requirements of operating these facilities, a privately financed, cogeneration system or "Power-Pak" addition is nearing completion at ETEC and is planned to begin operation in FY 1988. The addition of this cogeneration system will provide revenues from electricity sales which will partially offset operating costs and provide low-cost steam generator performance and endurance testing.

ETEC focuses on non-nuclear testing of liquid metal components with an emphasis on steam generator performance and endurance testing, which is conducted at the Sodium Component Test Installation. In FY 1989, initial performance testing of the 70 thermal megawatt (MWt) helical coil steam generator will be conducted utilizing the "Power Pak" electrical-generation

revenue to significantly offset test costs. LMR design verification testing and testing in support of the SP-100 program will also be conducted at other ETEC facilities. Also in FY 1989, under a cooperative program with the Japan Atomic Power Company, the facility modifications required for the future testing of the DOE double-walled tube steam generator and for a Japanese test model will be initiated.

The ANL-W site is the technology center for the metal fuel development program and for reactor operations and metal fuel reprocessing, fabrication, and waste treatment demonstrations to verify the closed metal fuel cycle. At the ANL-W Experimental Breeder Reactor-II (EBR-II) and Transient Reactor Test (TREAT) facilities, test programs such as waste management, fuel performance, failed-fuel testing, passive reactor safety testing, and criticality experiments are being conducted. During FY 1989, the conversion of the EBR-II core to a composite of binary and ternary alloy metal driver fuel will be completed, automated control strategies fully compatible with passively safe plant response to upsets will be demonstrated, and transient overpower tests of passive safety and the operational transient program will be conducted. Modifications will continue on the ANL-W Hot Fuels Examination Facility (South) for metal fuel refabrication, reprocessing and waste treatment technology development and verification, and qualification and acceptance testing of systems will be initiated. After completion in FY 1988 of the SP-100 final core design tests, the Zero Power Physics Reactor (ZPPR) at the ANL-W site will be maintained in a standby condition, except when a program test sponsor provides funds to cover operating costs.

As a part of meeting our commitment to support key universities to conduct nuclear R&D, DOE has formulated an opportunity for Argonne to serve as a catalyst in implementing significant college and university multidisciplinary research around the EBR-II and the IFR concept. Faculty and students at U.S. colleges and universities will be provided an opportunity to participate in "hands-on" experience across the broad spectrum of nuclear engineering--an element that utilities and other prospective employers of engineers consider to be vital.

The FFTF serves as a national multipurpose facility. Test programs required for space and defense programs, fusion, isotope production, and international programs are being conducted. Activities to be conducted in FY 1989 include tests for the space and defense energy program, including irradiation of a prototypical SP-100 fuel test article, fuel and blanket tests under a cooperative DOE/Japanese agreement, tests for the fusion program, and the initiation of a long-range upgrade program for selected FFTF reactor systems equipment. In FY 1989, FFTF operations with binary metal driver fuel will be initiated, and the complete irradiation of the first prototypical ternary (U-Pu-Zr) metal fuels test assembly will be completed.

In addition to these facilities, the Integrated Equipment Test (IET) facility at the Oak Ridge National Laboratory (ORNL) provides unique capabilities for developing and demonstrating remotely operated and maintained equipment and systems. These are mainly used in support of

oxide reprocessing, but are also applicable to other hazardous operations and environments, such as reactor maintenance and operations in space. The IET is being utilized to conduct a major multi-year oxide reprocessing exchange agreement with Japan-PNC and to carry out other international technology exchange agreements in the fuel cycle area with the United Kingdom, France, and the FRG.

SPACE AND DEFENSE POWER SYSTEMS

The Space and Defense Power Systems program is an important element of the Department's Nuclear Energy R&D effort. The program's primary mission is to develop nuclear energy systems to respond to requirements identified by the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD), including the Strategic Defense Initiative Organization (SDIO). Program activities include the design, development, and technology support for building and testing compact, high performance reactors for space and terrestrial applications and dynamic isotope power systems for space application. In general, these power systems and the technologies developed in this program are intended to operate in remote and demanding environments, independent from logistical supply chains. In many cases, they represent the only power sources capable of fully meeting user mission requirements. Currently, the emphasis is on space power systems. The program comprises three firm projects--the Dynamic Isotope Power System (DIPS) in the range of one to ten kilowatts of electric power (kWe); the SP-100 Space Reactor in the range of tens to hundreds of kWe; and the

Multimegawatt (MMW) Space Nuclear Power Program which covers the range from several to hundreds of megawatts of electric power.

The Department has undertaken these nuclear energy projects to meet expanding space and defense requirements as part of its overall nuclear development charter under the Atomic Energy Act to support other Federal agencies as well as civilian energy needs. In each case where DOE is proposing funding, it is as part of a joint project, cooperatively funded by DOD and/or NASA. Our space reactor projects build on the technologies developed as part of our civilian power reactor programs, primarily the liquid metal and gas-cooled reactor programs. It is anticipated that eventually there will be meaningful feedback to the commercial reactor programs from accomplishments of the space power programs, particularly in the areas of fuels and materials, and reactor control.

For FY 1989 the DIPS program increases from $6.3 to $21 million as a result of increased design, fabrication and testing activities under a recently awarded systems integration contract. The increase also provides resources to support modifications to facilities at the Hanford site near Richland, Washington. These modifications are necessary to conduct future DIPS fuel module assembly and testing and to continue base radioisotope power generator projects. The DOD is considering this power source for use on the Boost Surveillance and Tracking System (BSTS) as well as on other missions. Similarly, the MMW program shows an approximately $10 million increase primarily to support detailed conceptual design studies being performed by industrial contractors. The SP-100 program funding remains

essentially constant as a result of increased NASA participation and interest as a funding partner over the remainder of the program.

The combined funding request for DOE's Space and Defense Power Systems program increases from $75.3 million in FY 1988 to $117 million in FY 1989. This funding request includes a $15 million "fair share" irradiation and test charge for use of DOE test facilities. The key point regarding the funding levels for the Space and Defense Power Systems program is timing. For example, if the SP-100 reactor system is to be available and proven by the mid-1990's as desired by DOD, and if we are to be in a position to select one multimegawatt space reactor concept by 1992, then certain activities must be conducted now. The funding we have requested in FY 1989 is the amount needed to conduct all of these activities and to maintain a schedule commensurate with DOD's needs. Lower funding levels will simply not permit the availability of the various power sources by the desired need dates with the necessary confidence in the technology.

SP-100 Space Reactor Project

The triagency SP-100 program, begun in February 1983, will continue in its Technology Readiness phase during FY 1989. In 1985, the first phase of the project was successfully completed with the selection by DOD, DOE and NASA of a reactor concept utilizing thermoelectric energy conversion for development and testing and the selection of the preferred site for conducting a ground reactor demonstration test.

In late 1986, the system development contractor team, led by the General Electric Company, was selected and the SP-100 Ground Engineering System (GES) Program moved rapidly to integrate system developer activities with the previously established project team.

Early in 1987 the SP-100 Steering Committee (comprising DOD, DOE and NASA representatives) reduced the reference design power level from 300 to 100 electrical kilowatts. This decision was driven by user assessments of power level requirements associated with early missions compatible with the SP-100 power system. With funding shortfalls identified at the time of this decision, it also became necessary to extend the program an additional year. The required reprogramming was completed satisfactorily and, although the reference test power level was reduced to 100 kWe, the ability to use SP-100 technology from a few tens to hundreds of electrical kilowatts has been maintained.

Furthermore, FY 1988 funding levels for both DOE and SDIO have forced an additional restructuring of the program. These changes were partially offset by increased NASA participation in the SP-100 GES Program. The commitment by NASA for FY 1988 funding and for substantially increased funding in FY 1989 through FY 1992 allows the SP-100 GES Program to maintain a sufficiently broad and balanced approach to develop and validate space reactor technology on a schedule which is still compatible with projected user needs, but the replanning has eliminated any contingency in meeting the FY 1992 target. Any substantial future funding shortfall will

require additional replanning of the program and would likely impact the ability of the program to meet cost and schedule goals.

Completion of a concerted design effort in August 1987 resulted in innovative design features to protect the core from a loss of coolant accident and to reduce system mass. The 100 kWe system design activities are proceeding as planned, both for the Generic Flight System and for the facilities and equipment needed to perform the ground testing of the reactor at WHC. In addition, substantial progress has been made by all project participants in implementing requirements for quality, reliability and safety programs.

In FY 1988, major accomplishments will include the final Generic Flight System design that will form the basis for the ground testing of components and assemblies to validate the performance and lifetime of the SP-100 power system. Component hardware will be designed and tested, and fuel for the reactor at the ground test site will be fabricated. The definitive design of the site facility modifications will also proceed, with major procurements of equipment occurring in FY 1989. Safety analyses will be performed to support the planned reactor tests.

Because of the recent replanning efforts, some activities initially planned for 1988 completion will continue into FY 1989. Major accomplishments in FY 1989 will include completion of the reactor test site definitive design and Preliminary Safety Analysis Report (PSAR), initiation of the fabrication of the vacuum vessel and modification of the existing reactor

containment facility in which the GES test will be conducted. Key technology development activities will continue at the supporting national laboratories. In particular, most of the fuel production for the GES reactor test will be completed. Fuel and material testing and post-irradiation examination will continue at EBR-II and the FFTF. The system contractor will continue with the design, analysis, development, and testing of system components. Design of the major reactor ground test--commonly referred to as the Nuclear Assembly Test--will be completed and test article fabrication will commence. In preparation for a flight decision, planning with the user and system contractor is expected to be initiated, and the systems contract will be appropriately modified to permit the flight option to proceed at the outset of FY 1990.

Multimegawatt Space Nuclear Power Program

In 1985, the Multimegawatt Space Nuclear Power Program was established as a joint DOD/DOE program to meet power needs beyond those satisfied by the SP-100, in the range of a few MWe to hundreds of MWe. The program contains three elements--the MMW Space Reactor Program, the Thermionic Fuel Element Verification Program (TFE), and Centaurus.

The primary goal of the MMW Space Reactor Program is to identify at least one space nuclear power system concept by 1992 that meets the high performance, multimegawatt power requirements of advanced Strategic Defense Initiative (SDI) applications, and to resolve all feasibility issues by that time.

The MMW program is geared to push reactor, power conversion, and storage and heat rejection technologies well beyond that to be achieved in the SP-100 program. In a phased approach, the program is targeted to reach the stage of concept selection in FY 1992, similar to the status of SP-100 in FY 1985.

In March 1987, DOE completed scoping work on the definition of MMW reactor systems concepts and requirements, and incorporated the results into a Request for Proposals for five to eight preliminary system concept studies. These studies will include analyses, tradeoff comparisons, identification of technology feasibility issues, conceptual design configurations, and development plans for MMW space reactor power supplies. The six contractors selected in late January 1988 will perform system studies over a 10-month period beginning in mid-FY 1988. We expect to select two or three concepts for further development by mid-FY 1989. Concurrent with the contractor studies, supporting technology development activities will be performed at national laboratories. Potential technology efforts include the production of zirconium-coated uranium carbide fuel particles and particle bed fuel elements for FY 1988 fuel tests; demonstration of fabrication processes for uranium carbide fuel cermets; testing of properties and fabricability of high-temperature refractory alloys; and development of energy storage technologies.

Other activities planned in FY 1989 and beyond include the completion of a preliminary safety assessment for the selected concepts, resolution of feasibility items identified in the initial detailed system concept

evaluations and tradeoff studies, detailed design configuration and specific component selections, and a further development plan and ground engineering system test configuration. The technology development program which focuses on and directly supports the selected two or three concepts will be pursued by industrial contractors with national laboratory support. Emphasis is expected to be placed on fuels and materials and on heat rejection. Upon completion of the second phase in 1992, at least one concept which meets the MMW program goals will be identified for possible selection by the SDIO to proceed with further development and testing during the mid-to-late 1990's and early next century, respectively.

Also included in the jointly funded MMW program are the TFE verification and Centaurus programs. The purpose of the TFE verification program is to provide sufficient irradiation performance data on thermionic fuel elements to allow their further consideration for MMW and other space power applications. In FY 1988 accelerated irradiation tests are being conducted in FFTF with similar tests planned in both the FFTF and EBR-II in FY 1989. Based on test results and modeling input, design and fabrication of a prototype TFE assembly will be initiated in FY 1989 for subsequent real time irradiation in the FFTF.

The Centaurus program is targeted to complete the current phase of tests by the end of FY 1990. To that end, a test is planned for the TREAT reactor in FY 1988 and the design of another test is planned by FY 1989. Advanced concepts continue to be explored and benchmark reactivity and mockup flow tests are planned for FY 1989.

Irradiation and Test Charges

This program activity is to account appropriately for the increasing use of the Department's test facilities by the Space and Defense Power Systems Program. The proposed $15 million for FY 1989 represents the approximate proportional usage by the Space and Defense Power Systems Program relative to total facility use. Each program user still pays its incremental test costs, such as for test capsules and safety analyses. The high burnup fuel and material tests are essential to the success of the Space and Defense Power Systems Program.

Dynamic Isotope Power System

The needs of military spacecraft in the planning process include higher power requirements and increased survivability to threats directed at disablement or destruction of the space system. The current standard spacecraft power source, large and potentially vulnerable arrays of photovoltaic cells, may not meet all future military spacecraft survivability requirements. One class of spacecraft of current interest for high priority missions projected for the 1990s requires electrical power in the range of 1 to 10 electrical kilowatts, stringent attitude control and station keeping, and survivability from various threats.

The Dynamic Isotope Power System--an isotope-fueled power subsystem with a combined turbine-alternator--is an enabling technology for those military space missions that require survivability against various threats, higher power, and a small power supply to improve the fields of view of the

sensors and the overall spacecraft pointing accuracy. This joint DOE/DOD demonstration project was initiated in FY 1986 under a supplemental agreement between the two departments. This agreement set up a cost-sharing arrangement, with DOD providing about two-thirds of the funds.

The primary objective of the DIPS project is to select, develop and demonstrate the necessary hardware required to provide a dynamic-conversion, space electrical power system in the range of 1 to 10 kilowatts output for use by emerging military and civilian space missions in the early 1990's and beyond. The DIPS project is focused on meeting the power needs of the BSTS system.

The DIPS project will demonstrate that all key technological issues have been addressed successfully through the design, fabrication, and testing of electrically heated Engineering and Qualification units. The Department has selected Rockwell International as the lead contractor to design and build a DIPS Engineering Unit and a DIPS Qualification Unit for ground testing. The major DIPS project goals during FY 1988 are the completion of the contract negotiation and the provision of support to the Air Force in system tradeoffs for the Boost Surveillance and Tracking System.

In FY 1988, the DIPS contractor is initiating a review and assessment of the Brayton and Organic Rankine conversion cycles, identifying critical components and beginning their testing, and initiating systems conceptual design studies. The procurement and manufacture of long-lead heat source

materials are being implemented in FY 1988 in order to support a safety test program in FY 1989.

Conceptual design studies of the heat source/heat exchanger for both the Brayton and Organic Rankine cycles will be pursued by a DOE technical support contractor, in conjunction with DOE laboratories, to support the DIPS lead contractor. Brayton/Organic Rankine conversion cycle technology assessments and system conceptual design studies will be completed and a cycle/design concept will be selected by DOE with DOD concurrence. Additional FY 1988 work includes initiation of the DIPS Engineering Unit Design.

In FY 1989, the DIPS Engineering Unit Critical Design Review will be completed and the proposed design approved by DOE. The procurement of long-lead items and materials for the DIPS Engineering Unit manufacture will be initiated, and fabrication of the Engineering Unit will begin. Reliability, survivability and safety studies will be conducted in parallel with the Engineering Unit design activities and will complement these design activities. A System Safety Program Plan will be developed by the DIPS contractor and approved by DOE. Critical component development, performance, and life testing will be continued.

A new construction project is planned to be initiated in FY 1989 to modify an existing DOE facility to provide fuel production capability for both the DIPS and radioisotope thermoelectric generator (RTG) projects.

Pending a selection of DIPS by DOD to power BSTS and the approval of Supplemental Agreement No. 2 to the DOE/DOD Interagency Agreement, a DIPS Flight hardware project would be implemented so that DIPS flight units would be available on the BSTS schedule. DOE expects to execute this second supplemental agreement later this year.

ADVANCED NUCLEAR SYSTEMS

The Advanced Nuclear Systems (ANS) program develops, demonstrates, and delivers radioisotope power sources for U.S. military and civilian space and terrestrial missions. Included in the program are the base level support for fuel production and testing, nuclear safety analysis and testing, quality assurance, reliability and operational safety for DOD/SDIO/NASA missions that use, or will use, isotope power systems. DOE plans to continue to maintain a viable heat source production capability within its laboratory structure in order to support future RTG deliveries. This laboratory structure provides a national capability to support DIPS, special applications RTGs, and future NASA missions. In 1988, DOE is maintaining and upgrading heat source production and RTG fueling capabilities.

Current programs supported under the ANS decision unit include the NASA Galileo and Ulysses missions, DOD Special Terrestrial Applications, and flight systems support to the DIPS program for Air Force and SDI applications. All of these projects are jointly funded with DOD or civilian agencies. Future missions on which isotope power systems are

planned for use are Mariner Mark II (a series of NASA interplanetary missions in the early 1990's) and a DOD Special Terrestrial Applications project in the mid-1990's.

A major effort during past years under the RTG portion of the ANS program has been the design, fabrication, and delivery of the General Purpose Heat Source (GPHS) RTGs, preparation of safety analysis reports, and delivery of radioisotope heater units for the NASA Galileo and Ulysses missions. The delay in the first launch to 1989 added appreciably to the remaining pre-launch activities, particularly in the safety and the RTG testing areas. Since the January 1986 Challenger accident, DOE has been working closely with NASA to prepare new Final Safety Analysis Reports (FSARs) as a result of new launch requirements. While preliminary analyses indicate no problems, confirmatory tests are being run by DOE in FY 1988 to complete the FSARs to support a FY 1989 launch date.

New tests and an extensive set of new analyses--in some cases, using new models--will be required to incorporate the findings from the Challenger and Titan 34D accidents and potential impact on RTG's. Thus, full funding of the safety and technical support organizations as well as the system contract efforts is essential if DOE is to complete the first FSAR in 1988 to support a 1989 launch, and the second FSAR in 1989 to support a 1990 launch.

In addition, there are numerous activities keyed to work on both the Galileo and Ulysses missions as well as the terrestrial RTG program. For

example, DOE is protectively storing and monitoring the four flight RTGs for Galileo and Ulysses. DOE is also conducting long-term performance tests ("life tests") on a Qualification Unit to confirm reliability and power predictions for the Galileo and Ulysses missions. The launch delay, coupled with the new upper stage for Ulysses, will require an adjustment in the internal structural support of the RTG to hold the heat source modules in place. This is a major operation almost akin to disassembly, reassembly, and acceptance testing on two RTGs. This work will have to be completed in 1988 to support a 1989 launch option for the Ulysses mission. This requires a major resource commitment to the DOE Mound Plant in Miamisburg, Ohio.

In looking to the future, DOE is continuing to pursue the technology and the development of an advanced modular RTG that offers the promise of higher power density and greater size adaptability for the next generation of DOD and NASA missions, such as the Mariner Mark II. The modular concept to be employed on the generator will enable NASA to accommodate a range of interplanetary missions. During 1989, thermoelectric modules will be produced and assembled into a ground engineering system for demonstration tests.

In parallel with the advanced modular RTG development, DOE is continuing its efforts to improve thermoelectric conversion efficiencies, including silicon germanium optimization, electrical contacting, evaluation of materials properties, degradation mechanisms, and material interactions.

In 1989, several laboratories working on heat source efforts will start production activities for the DIPS flight program. DOE will also continue those efforts necessary to improve heat source safety, improve production efficiency to reduce heat source costs, and continue work in long-lead areas. Included is the redesign and design verification of changes to the GPHS-RTG to improve safety and performance for future missions.

To meet DOE obligations to deliver RTGs for terrestrial military missions, the Special Applications program will continue its efforts to develop and demonstrate the necessary technology. During 1987, an engineering demonstration unit was placed on extended life testing, and testing of thermoelectric modules continued. DOE also delivered three 5-watt RTGs in 1987 to DOD under a reimbursable agreement. During 1989, DOE will continue design and integration studies for specific missions, continue testing of the engineering unit and thermoelectric modules to develop reliability data, and complete tooling requirements for modifications at the Mound Plant for the fueling, assembly, testing, and delivery of a 180-watt RTG late in the fiscal year. DOE will also continue the safety qualification of a small, sealed, terrestrial heat source to meet projected DOD requirements for small RTGs in the early- and mid-1990's.

The CHAIRMAN. Thank you very much, Mr. Garrish.

Would you discuss the question of using the production reactor as the demonstration project for a passively safe reactor?

Mr. GARRISH. The question is currently before the Department to evaluate all of the potential designs for reactors to determine which would be the best. As the Secretary testified here before the committee, there are questions on the technologies and determining whether or not those technologies can in fact produce the nuclear materials that are required.

His concern, and I think he emphasized this, is that the various potentials need to be examined. The gas reactor needs to be looked at very closely as a possible alternative.

But it is extremely important that these reactors can produce the products that are needed for defense security, and that probably will be the foremost consideration in whether or not our reactor development time frames can be met with this new production reactor.

The CHAIRMAN. When are you talking about making that decision to pick a reactor?

Mr. GARRISH. I believe the process for technology and site selection will begin this summer.

The CHAIRMAN. This summer?

Mr. GARRISH. Yes, that is correct.

The CHAIRMAN. And how will you go about making the decision?

Mr. GARRISH. Mr. Bunch I think can respond to that more thoroughly.

Mr. BUNCH. That program is in the Office of Defense Programs, but the basic process is as follows. The Under Secretary has created, through a group which is called the Energy Research Advisory Board, a sub-group to look at technology choices. They will provide a report on the various technologies and their ability to reliably meet tritium production requirements.

There is a separate group that is examining the various sites that might be useful for that. What that group is looking at is how would you match up the various technology options with the existing facilities within the Department's complex, those dealing with tritium production, fuel fabrication, and the like.

Those two reports will come together and try to see what match best meets the Department's needs for tritium production.

The CHAIRMAN. The Department of Defense will make a judgment this summer and they will just pick a reactor, pick a technology?

Mr. BUNCH. Excuse me. This is Defense Programs, a group within DOE.

A recommendation will be made to the Department from this energy research advisory group, which has a number of——

The CHAIRMAN. To the Department of Energy?

Mr. BUNCH. To the Department of Energy, yes.

The CHAIRMAN. And the final decision will then be made?

Mr. BUNCH. It is my understanding that the recommendation will be offered to the Secretary and the Under Secretary in the summer time frame, and presumably the selection will be made shortly thereafter.

The CHAIRMAN. Well now, is there any input, any formalized process or informal process for input from people outside the Department of Energy?

Mr. BUNCH. This energy research advisory board panel consists largely of people outside the Department of Energy. They have convened, I think, about a dozen meetings so far in which representatives from various vendors have offered their propositions on what would be a sensible technology to meet the Department's requirements.

So there has been a whole host of discussions with people outside the complex.

Senator FORD. Mr. Chairman, are these vendors? These are vendors that comprise the board?

The CHAIRMAN. They speak before the board.

Mr. BUNCH. Speaking before the board, Senator Ford.

The CHAIRMAN. The board is made up of outsiders to the Department of Energy?

Mr. BUNCH. Yes, sir. They include individuals such as Floyd Culler, who was formerly head of the Electric Power Research Institute until he retired this year. And I think there are about a dozen individuals who had involvement and expertise in nuclear technology.

The CHAIRMAN. Now, the board will then make the recommendation to the Department of Energy?

Mr. BUNCH. That is correct.

The CHAIRMAN. Do you have a methodology within the Department of Energy as to how you would make a decision?

Mr. BUNCH. It may be better to provide that for the record, Senator Johnston. There is a very deliberate process for first arriving at the composition of the board and then getting the board's reviews, then getting the board's report, at which point there is a process, with which I am not fully familiar, on how you take that information and proffer a specific recommendation to the Secretary.

[The information follows:]

To ensure the effective implementation of the production plans, DOE has developed an acquisition strategy for the NPR. This strategy begins with in depth evaluations of candidate technologies and sites and includes preparation for several procurement actions. The decisions on the technology and site selections will be made by the Secretary of Energy, based on analyses and evaluations provided by the Energy System Acquisition Advisory board (ESAAB). The ESAAB is composed of the Under Secretary; Assistant Secretary, Office of Management and Administration; Assistant Secretary, Office of Environment, Safety, and Health; Assistant Secretary, Office of Defense Programs; Director of Energy Research; and Director of Administration. The ESAAB will be assisted by two panels; namely, an Energy Research Advisory Board (ERAB) panel that will assess reactor technologies and a DOE staff group that will evaluate sites. In addition, the ESAAB will consult with the Department of Defense (DOD) Nuclear Weapons Council and the Science Advisor to the President. As part of the information provided to the Secretary, the ESAAB will provide analyses and evaluations of procuring, either concurrently or sequentially, two or more production reactors of the same or different technologies at one or more sites.

The CHAIRMAN. Well now, I would foresee, if we put in legislation on this subject, various ways we could do it. One might involve that production reactor, because after all we are going to have to fund that production reactor. And it seems to me it might be appropriate at some point to have the recommendation from your

subgroup which is then transmitted to Congress, where we would hold hearings on it, so that we could bring in not only the experts you have heard from, but people in the electric power industry and some of these same witnesses.

But after all, it is a judgment not only about the technology, of how well you can produce tritium, how long it takes, and what the cost is, but it is a question that would also involve potentially the building of this new kind of passively safe reactor, which might be part of the solution in the future.

Can you tell me, Mr. Garrish, what your reaction to that is?

Mr. GARRISH. My reaction is that the Department will be working very closely with the Congress in order to take steps on the New Production Reactor. This is not something that happens unilaterally within the Department. It is a very significant development for the government. It is a very expensive project.

There are a number of people in the Congress that we will be consulting with. I think that there will be some opportunities to have some discussions about that. Obviously, we do have some problems with classification issues that arise, but I expect that we will be fully involved with the Congress on that decision.

The CHAIRMAN. Well, I wish you would go back and see if you can give us some kind of assurance that before your decision is final, that you would allow us—that you could submit to us your preliminary findings and let us hold some hearings, secret if necessary, but at least some hearings, to be involved in the process.

That might obviate the need for trying to build a formal matrix of rules and regulations as to how we finally make the decision. If we have the opportunity to be involved, I suspect we might well come to the same conclusion and not have to have a whole legislative package.

Mr. GARRISH. I fully support the approach you are suggesting. I think that there are some real advantages that we need to look at, but there are some real questions that are yet to be answered.

And certainly from my standpoint, we fully support the concept that we will discuss those questions with the Congress fully.

The CHAIRMAN. I understand there are about four technologies that you are looking at. Do you remember?

Mr. BUNCH. I believe there are in fact four. There are versions of light water reactor technology; there is a heavy water technology option, somewhat analogous to the Savannah River plant; the high temperature gas-cooled reactor; and a sodium-cooled reactor.

Each concept has been suggested to this board.

Senator DOMENICI. Mr. Chairman, would you yield for an observation?

The CHAIRMAN. Certainly.

Senator DOMENICI. Are you suggesting, Mr. Chairman, that they, in considering the recommendation, that they also consider the aspect of new technology that might lead to a more acceptable type of reactor, either functionally or environmentally?

The CHAIRMAN. I think they are in fact doing that. As he pointed out, there are four technologies there, all of which would have some passively safe aspects. Even the light water reactor process being considered is more passively safe or better engineered.

It would have, as I understand it, cooling water that does not depend on pumps.

Mr. GARRISH. These would all be state-of-the-art. Whichever of the technologies we choose, we are going to look for the safest possible reactor, and the passive features of each of the technologies will be important for our consideration.

Senator DOMENICI. Thank you very much.

The CHAIRMAN. Senator Evans.

Senator EVANS. Thank you, Mr. Chairman.

First and just a commentary, warning bells go off all over the place as far as I am concerned if we start mixing up the national security needs with new research and new development, which is always somewhat uncertain. It seems to me that we have got some very, very big potential problems, and we need the absolute certainty of production for national security, and especially with the rather old and creaky plants that we are depending on now. We need it as soon as we can get it.

I would be interested in seeing how we can combine things together when at least we have some surety of national security requirements. If we are only going to deal with one, if we are only going to abandon the fundamental concept of redundancy, which we have had in the past in production reactors for national security purposes, then I think we have real problems.

If we are not going to abandon redundancy and we are looking at the potential of a redundant system of reactors, then it seems to me that at least one of those really does fit what the Chairman is talking about, the opportunity to do two things at once.

But if we want to do just one and depend solely on that one for national security needs, then it seems to me that it is way too dangerous to try to combine that with new technologies.

Mr. GARRISH. I think our approach is not to preclude any of the technologies and to examine them fully as to all of their potentialities, with national security being the first and foremost interest.

Now, I think the other answer to the question is that we need to move forward with our other programs on civilian advanced reactor development, and that is an extremely important part. It is not necessarily tied to this. In other words, that is a part that is in the Nuclear Energy Office.

We need to continue to emphasize that. I think this does offer an advantage that we need to take a look, at. We need to look at all of these technologies simultaneously.

Senator EVANS. Let me ask you a few questions on the FFTF. I understand that you have been conducting an internal search on the long-term utilization of the FFTF, examining a series of potential future missions, a variety of them which you may want to describe.

What is the status of that report and when is it going to be ready? Can you give me some direction as to where that study may be leading, or is it too early to tell?

Mr. BUNCH. Senator Evans, as you point out, we have had under way, since the N reactor decision was made, an effort to examine again alternative uses of the FFTF, and we have had a variety of potential uses identified for us, which we considered.

Where things stand at this point is that we have identified what I will call three general classes of missions that might be appropriate for that machine; and are looking at the technology risks associated with those, the funding implications associated with those, and the impact on the balance of the program of selecting a mission, perhaps to the detriment of others.

It is our intent to complete that evaluation right around Memorial Day and provide a final report to the Under Secretary.

Senator EVANS. Good.

If the FFTF is going to have multiple missions, which it seems to me it probably ought to have to be operated most efficiently and maybe even to survive, do you think that potentially the following mix of missions could be compatible: PU-238 production, testing of steam generators for the Japanese Monjo program, and power addition to the FFTF using byproduct steam.

Now, those are a variety of different directions. Would it be compatible to be doing that variety of things with the FFTF?

Mr. BUNCH. Each of those missions, as we understand it, could be conducted in the Fast Flux Test Facility complex. The difficulty we have had in going forward with such an aggregation of missions is that to provide assurances to the community that would offer private financing for a power addition, for example, we have to be able to assure and guarantee basically that the plant is going to be on line for a fairly long period of time.

Similarly with the Japanese, we need to make sure that they are prepared and committed towards providing the funding that would be necessary for them to conduct steam generator testing at that reactor.

And finally, in terms of plutonium 238 production, we need both to examine the requirements more completely as well as the equipment and hardware that would be needed in the FFTF and adjacent facilities to fully outfit it so it could do 238 production.

And it is still a little too early to say about it.

Senator EVANS. Those are all elements that you are looking at in this study you are conducting?

Mr. BUNCH. That is correct.

Senator EVANS. It is my understanding that FFTF is now expected to receive an appropriation for fiscal 1989 of $63 million, $53 million for operating and $10 million for testing.

If funding is not increased beyond that level, I have some I think pretty reliable information that the reactor cannot last beyond 1991 or 1992, in fact that it will run out of fuel by that time and not be able to test any of the metal fuel that it is scheduled to do post-1991.

Is that accurate?

Mr. GARRISH. Senator, at this stage the Department is committed to solving the fuel problem with the FFTF, and the numbers that you quote are correct. But we need to deal with that problem, and the Department is committed to solving that issue.

Senator EVANS. But then solving the issue requires in essence additional funding, does it not?

Mr. GARRISH. I am not certain that it requires funding in this budget.

Senator EVANS. Well, if fuel is going to run out, you cannot wait and start getting to that point. You get to a point where you cannot fill the gap, is that not correct? It will run out of fuel and if you start the funding several years from now you are not going to be able to get the job done.

Mr. BUNCH. If I may, the review of the future missions for the Fast Flux Test Facility requires that we look at our financial obligations in 1988, 1989, and the out years. I think what we are trying to do is make sure that we have a global view of what it is going to take to run that facility efficiently and safely. If we go to a plutonium-238 option, for example, it is going to require a considerable amount of money to refurbish that facility.

And so what we want to do is make sure that we have an integrated plan for fuel, for equipment, for operating staff, and we need to look at that as an integrated package.

And if we have to make some funding adjustments to permit that, then to the extent it can be done within the existing budget it will be done. So if it requires supplemental funding or adjustment to our fiscal year 1990 budget, then we will have to make that adjustment as well.

Senator EVANS. In looking at the fiscal year 1989 budget, would this, the answers to the questions you just posed, would they come out of the study which you say will be ready by Memorial Day?

Mr. GARRISH. That is correct.

Senator EVANS. So at that point you would have some information as to whether additional funding is required, either in 1989, 1990, or beyond to carry out the missions you think are appropriate?

Mr. BUNCH. Yes, sir.

Senator FORD. I might remind my colleague that that is next week.

Senator EVANS. That is right. Just when we come back from recess, we should have that information.

Mr. GARRISH. We do not want to prejudge the determination of the Under Secretary when he receives the report. He will have the information.

Senator EVANS. He does want to have time to read it and act on it, I guess.

Finally, on waste burn, you mentioned the possibility of using—on page 17 of your testimony, you mentioned the possibility of using FFTF or other liquid metal reactors as an actinide burner that could greatly simplify nuclear waste management.

Would you care to expand on that?

Mr. BUNCH. That particular reference is to an analysis by some individuals at Hanford. Basically, the proposition is as follows. The reactor has a neutron spectrum which would allow the reactor to be used to convert waste products, such as cesium or technesium or other highly radioactive materials that are in liquid wastes or other wastes from fuel, to be converted to much less harmful, much more short-lived materials.

The proposition was basically to see whether or not you could do so efficiently in this kind of reactor. It would be a very long-term option that might be explored and would in no way obviate the need to proceed promptly with the high-level waste repository.

Senator EVANS. One final question, and then I do have some others for the record in order to try to minimize the time here.

On page 35 you talk about at the bottom of the page that DOE is continuing its efforts to improve thermoelectric conversion efficiencies of various kinds. Now, you are dealing within the framework in that part of your testimony of advanced nuclear systems.

Would that have any implications at all in such things as solar, direct photovoltaic operation, which is I guess a form of thermoelectric conversion?

Mr. BUNCH. Yes, Senator, it does have the potential for some technology transfer benefits to non-nuclear technology. The particular item referred to what we call our RTG program, or Radioisotope Thermoelectric generator program. To the extent that we can find a technology which will get us better energy conversion, I think that would be valuable to solar as well.

Senator EVANS. If you get to a point where energy conversion is economically within the ballpark, in the future does it make any sense at all to even examine the potential of the photovoltaic conversion of solar to electricity to hydrolized water and to recapture the hydrogen as a potential fuel for the future?

Mr. BUNCH. As I understand it, there have been a number of reports by the National Academy of Sciences and others that looked at emerging technologies for the nineties. All of those with which I am familiar have concluded that it is indeed worthwhile to continue to explore solar technologies for their value for a lot of uses in which radioisotope technologies might simply be more expensive or not appropriate because of proximity to populations.

It is my opinion that we would find that improvements in energy conversion would just increase the domains in which we have opportunities for energy conservation. And so I think the programs are not mutually incompatible, but rather supportive.

Senator EVANS. Thank you very much.

Thank you, Mr. Chairman.

The CHAIRMAN. Senator Ford.

Senator FORD. Thank you, Mr. Chairman.

Mr. Garrish, just a couple of quick questions. Under the current management, the advanced reactor program spends about, I understand, about half its time on defense tasks and about half on civilian. Is that correct?

Mr. GARRISH. That is more or less correct, yes.

Senator FORD. Does not this mode of management create conflicts that are usually going to be resolved on the side of defense?

Mr. GARRISH. I do not believe necessarily that conflicts would be decided that way. You do have to understand that when we do these projects we do them for our clients, and our clients would either be the Department of Defense or NASA. It has been traditional that, even during the days of the Atomic Energy Commission, we would do the development on the reactors under a scheme that our clients would devise the project that they would be interested in, that we would do the development, and then they would do the actual flight of the particular project.

Senator FORD. Do you all listen to your energy research advisory board?

Mr. GARRISH. I hope so.

Senator FORD. Have they not advised against such procedure and, if not, at the least that the military pay its costs, because what you are doing, you are reducing the amount of research and development for the civilian reactor program, and in effect it is a cut in the civilian program if you operate that way and Defense does not pay for it.

We fund you and it goes to the military. Then the civilian research is being cut.

Mr. GARRISH. That assumes that we have a total pie in which it is divided up between the two. However, I think what we are trying to do is take a look at the individual merits of each project and determine whether or not this project should go forward.

And I think the budget is appropriate for the project level that we are discussing. But I do not think that one takes away from the other. We try to look at these individually as to the merits of the individual projects.

Senator FORD. Well, the money that we are budgeting does what? What does it go for?

Mr. GARRISH. It generally goes, in this particular area, for reactor development, which would be of use for both the civilian NASA requirements and for defense requirements.

Senator FORD. And so this money, none of it is funded out of the Defense Department into DOE, is that correct? DOE is funding defense, NASA, and everybody else, are we not?

Mr. GARRISH. I would not exactly put it that way. In other words, they have money with which they fund, through their particular budgets, certain aspects of these projects. And we have the development of these reactors in our budget. So they are basically divided up.

Senator FORD. Well, let us look at the budget a little bit, where next year it is $350 million. It is constant, but space and defense go up $75 million and $120 million, $75 million to $120 million, and advanced reactors drop from $92 million to $61 million.

Most all of them dropped, and then where your space defense goes up from $75 million to $120 million.

Mr. GARRISH. Your statement is correct that there are those changes. There are projects, ongoing projects which are requested by either the Department of Defense or NASA, depending on the individual requesting them, and they have a substantial contribution to each of those.

They vary by individual project. I would be happy to provide for you a listing of those contributions for each project, if that would be helpful.

[The information follows:]

SPACE AND DEFENSE POWER SYSTEMS
FUNDING PROFILE: DOE AND REIMBURSABLE FUNDS
($ in Millions)

	FY 87	FY 88	FY 89		Total Estimated Project Cost
SP-100 Reactor GES Test					
DOE	27.6	59.0	58.0		281.0
DOD	36.5	30.0	55.0		281.0
NASA	0.0	10.0	30.0		130.0
				Total	692.0
SP-100 Flight Option					
DOE	0.0	0.0	3.0		TBD*
DOD	0.0	0.0	10.7		TBD
NASA (Not budgeted at this time)	0.0	0.0	TBD		TBD
DIPS Demonstration					
DOE	9.0	6.3	13.5		62.6**
DOD	2.8	18.8	14.5		125.0**
				Total	187.6**

* TBD = To be determined.

** Total DOE and DOD costs being reviewed for possible reduction.

DIPS Flight					
DOE	0.0	0.0	7.5		TBD***
DOD	0.0	0.0	84.5		TBD***
				Total	TBD***

*** Total DOE and DOD costs subject to changes if DOD mission requirements and deployment schedule change. Individual elements being reviewed for possible reductions in cost.

MMW Space Reactor				
DOE	1.7	4.0	13.0	TBD
DOD	6.0	6.0	10.0	TBD
MMW Thermionic Fuel Element (TFE) Verification				
DOE	5.0	4.5	5.0	TBD
DOD	2.0	2.8	5.0	TBD
MMW-Centaurus				
DOE (Nuclear Energy)	0.0	1.0	2.0	TBD
DOD	2.4	3.0	3.0	TBD

Senator FORD. I think it would be helpful. Imagery is a great thing we all play on around here, but the image you are leaving from this is that it is a cut in civilian work. Everyone is cut except the defense and space, and that goes up from $75 million to $120 million.

So you are going to have to do a lot of explaining to this Senator. When you add up and subtract and it goes one way and it is short on the other side, it does not leave me with anything but a cut for civilian.

Mr. GARRISH. I understand your point.

Senator FORD. You inherited some substantial facilities from the Clinch River breeder program when it was cancelled. Have you been able to integrate these facilities into the missions of the Department without the breeder?

I know, it is a tough question, so it is shoved off to you.

Mr. BUNCH. Maybe it is because it is an easier one and perhaps more factual.

Senator FORD. Doctor, I understand what is going on.

Mr. BUNCH. I am sure you do, sir.

Since the fall of 1983, after the Clinch River plant went down, the Department had a very large technology budget associated with Clinch River. By and large, the last several years have seen a steady dismantling, if I can use that phrase, of that program to try to recognize, as Dr. Schlesinger was indicating earlier, that we simply do not need the breeder on the time scale that it was originally conceived of in the sixties.

Many of the facilities are no longer in existence or have been put on standby. We are left with fairly few numbers of active facilities, notably the reactor complex at Hanford and the reactor complex at Argonne National Laboratory in eastern Idaho. We have attempted, as I was trying to indicate to Senator Evans, to find ways to make those very expensive, very high class facilities useful to groups and individuals and programs for which there were emerging needs.

We are in a position in which I think we have achieved all reasonable economy with those facilities. We have found that they are very valuable for space and defense applications and are being used for the fusion program for materials testing.

And as I was indicating to Senator Evans, we may find that they have value for material production as well. In that context, I think it is important to preserve the option to utilize those few remaining facilities until we clearly understand what program the Department is going to carry out in the 1990's.

Senator FORD. What amount of breeder research are we doing now?

Mr. BUNCH. The breeder technology program is associated with the budget items called advanced reactor R&D and facilities. The advanced reactor R&D portion of it in the aggregate, in the 1989 request was $61.2 million. Out of that portion, I would say less than half of it is associated with one form or another of breeder-related technology.

Senator FORD. Do you believe that anyone in the utility industry is going to order an advanced light water reactor or high tempera-

ture gas-cooled reactor or liquid metal reactor until a working reactor is demonstrated at commercial scale?

Mr. GARRISH. Let me divide that question up. I think the industry is going to have to look very seriously at an order in the mid-nineties and even earlier. They need to be thinking about that prospect today.

Which of the types of reactors that would be depends a little on the development of our program and how far we go and what the date is. But I do feel that probably the next reactor that they would order would be an advanced light water reactor.

Now, if we can get some of the other——

Senator FORD. You are guessing on what they would do now, are you not?

Mr. GARRISH. They have indicated basically no interest in ordering any type of reactor right now.

Senator FORD. No volunteers out there.

Mr. GARRISH. No volunteers under the current conditions, and there are a number of reasons for that. Number one is that we need to work on our advanced reactor program.

We need to, number two, see if we can overcome some of these impediments that the industry has held out as very important to them. Their financial people have determined they would not put the kind of money behind these reactors with the licensing. The way it exists today, with the prudency reviews that they have to go through, with the lack of Price-Anderson, having not been passed, and with a variety of other things.

But the answer is that they have a number of impediments that they need to get over. I think we can deal with a lot of the technological questions. We are hopeful that Congress and the Administration can work through some of these institutional impediments.

And then the industry will need to relatively soon, if we can deal with those two problems, come up with sufficient funding to start to look at some type of prototype or some type of demonstration. If we can get the other elements in place we can then begin to work on some kind of demonstration or prototype project with the industry.

Senator FORD. Would it be in our best interests to go ahead and carry out the demonstration project and do it sooner rather than later?

Mr. GARRISH. I think it is to our best interests to try to do as much as we can in the advanced reactor program and to try to work on the legislative impediments, and then begin the process of trying to work with the industry on getting enough money together to try to work through that problem with them after the impediments have been dealt with.

Senator FORD. Well, I do not have any other questions. I could ask some more, but it is getting toward lunch time, and we have a panel.

I would suggest to you, if you read the statement by John Landis and look on page 8, it will give you some bedtime reading tonight as it relates to their advice and counsel.

Thank you all very, very much.

Next will be the industry panel: James O'Connor, Chairman and CEO of Commonwealth Edison; John J. Taylor, Vice President,

Electric Power Research Institute; and John Landis, Senior Vice President, Stone and Webster Engineering Corporation.

If you gentlemen will come forward, then we will move along. I have read your statements. Whatever you would like to do, maybe highlight it, your full statement will be included in the record and we can get to some of the questions.

Do you want to proceed, Mr. O'Connor.

STATEMENT OF JAMES J. O'CONNOR, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, COMMONWEALTH EDISON CO.

Mr. O'CONNOR. Thank you very much, Senator. And thank you for the opportunity to appear today.

I serve as Chief Executive Officer of Commonwealth Edison Company, a company that serves roughly eight million people in Illinois and has the largest commitment to nuclear power of any company in the nation. We have some twelve nuclear reactors, the last of which was given a full power operating license just this past Friday.

We have been in the business a long time and perhaps I can briefly sketch our history to indicate why we believe that the next increment of capacity that might be added would be the advanced light water reactor.

It has been almost 40 years, 1951, that our company joined a handful of others to examine the possibility of having or adapting nuclear power for peaceful purposes. Based on the study that we did, we agreed in 1955 to be the sponsor and site locator for the first large scale privately financed nuclear facility in the country, which was our Dresden plant.

That unit went into service in 1960, and based on the very favorable economic experience that we had with Dresden I, some five years later we decided to order our next two boiling water reactor units, also at Dresden. Shortly after that, we decided to order two more nuclear units, but this time of a pressurized water variety instead of the boiling water reactor.

The whole purpose of this program was to provide diversity in the kind of fuel supply that we had. We had been predominantly a coal-burning utility. We felt that it was important to have some flexibility, and our aim as we entered the 1960's was to shoot for a basic power supply which had a capacity component of 50 percent nuclear and roughly 50 percent coal.

And that is what we have today in terms of our base capacity. We simply felt it was extremely important to rely on the so-called hard fuels, nuclear and coal, for our capacity requirements.

What is interesting to note is that the plants that we put on line in the late sixties and early seventies went in at a cost of about five percent of what the plants being placed in service today are costing, a remarkable quantum leap in the cost of these nuclear facilities.

In 1987 our company provided about 66 percent of its total requirements through nuclear power. In fact, if we look just at the first quarter of this year, about 82 percent of our total requirements on a fairly large system came from nuclear power.

Had we had to use the next cheapest alternative, which in the case of our operation would have involved the use of low sulphur coal from the West, the cost to our customers would have been about $1.2 billion higher.

Senator FORD. Annual cost?

Mr. O'CONNOR. Yes, sir.

So we do think that the economics for nuclear on our system today have proven to be a real plus for our customers.

We talked earlier and the Chairman mentioned the need that we see between now and the end of the century for new capacity. Mention was made of the 100 gigawatts or 100,000 megawatts which is roughly equivalent to the total nuclear capacity that we have on-stream today, and that assumes the low growth of only about two percent.

The fact is, as was pointed out, load is developing quite a bit faster than that. There is an item in the Wall Street Journal this morning which you perhaps saw, which warns of the impending power supply situation that is going to develop or is expected to develop this summer in the Mid-Atlantic states, the prospects of brownouts.

And they point out that the average national load growth for the first quarter of this year was 4.8 percent, and that is about the level that we are experiencing nationally. And it does become a serious question as to the ability of the utility industry to meet that projected demand confronted with the constraints that we face today.

We talked earlier about the increasing use of electricity. It is so often said that the energy usage in this country is about what it was in 1973, but seldom is the distinction made between the use of electricity and the use of energy generally.

Notwithstanding the fact that the overall energy use is about the same as it was in 1973, the use of electricity is some 40 percent higher. I think that fact has largely gone unnoticed by the American public. We are picking up the slack.

Back in the 1970's when we had the drive for conservation, a very important drive, little attention was given to the supply side of the equation. And as a consequence, in our drive, and a most important and effective drive, for more efficient automobiles and air conditioners and what have you, we tended to neglect the very important part that electricity continues to play.

Just one brief footnote on that. When I joined my company 25 years ago, electricity only provided about 15 percent of our nation's total energy budget. Today that number is approaching 40 percent. So the momentum is there and it does tie very closely to the kind of growth that we see on the economic side in terms of GNP.

We ask where the energy is going and how is it being used, and we know that lasers, which are so prominent today in many areas, are reducing by a factor of 10 to 20 times the amount of time that it takes a conventional saw to do something.

We see in our steel-making facilities a 70 percent increase in the use of electricity for steel-making. And today about 37 percent of all the steel-making capacity is electric furnaces.

We see it in the wood industry, where we see kiln-dried material in lumber being reduced to one twenty-fifth of what it was just a

few short years ago. We see it in microwaves that are being used and electromagnetic waves that cure rubber in a period of minutes, rather than hours or days.

Indeed, we believe that if our nation is going to continue to enjoy the economic progress that is experienced in recent years, we are going to have to be there to provide the amount of electricity that is going to be required. Now, we have some problems in this area, in being able to meet those demands.

First, there is a great deal of unpredictability about the nuclear process. We have some five plants in this nation that have been under construction for over 15 years, and that is at a time where in other parts of the world they are completing plants in five or six years and talking about doing it in 48 months.

We have two plants up north at Seabrook and Shoreham that are being totally thwarted by local regulatory problems, notwithstanding the fact that they are ready to operate and that they do have acceptable emergency plans. And I believe that these plants serve as symbols of the political uncertainties which confront nuclear power today.

If local politics are permitted to override the technical judgment and the federal authority of the Nuclear Regulatory Commission, it is hard for us to see how electric utilities would ever be willing once again to consider nuclear energy as an option for their next increments of capacity.

Second, we simply have to find a way to make the costs less onerous, and in large measure that is a function of time. If we can reduce by one-half or greater the time it takes to put plants into service, then we will have a real opportunity to do something with the next increment of nuclear capacity.

And that is going to require that this Congress continue to do the sorts of things that it is has done so effectively this year in addressing the waste problem, in addressing the Price-Anderson question, and in addressing the uranium enrichment business.

All of these things have been most important steps in that direction.

Senator McClure's comment this morning that he is poised to present legislation that would provide for pre-approved siting of nuclear plants and for standardization would be a major step forward and an absolutely critical step to give the nuclear industry some assurance that we could rely on government prospectively.

Resolving these and other uncertainties is absolutely essential. We have been discouraged from making responsible long term decisions and from starting any large-scale projects.

It is interesting to know that every single nuclear power plant that was ordered after 1973 has been cancelled. These cancellations have happened for a variety of reasons. We had a slowdown of growth in the mid-1970's. We had the uncertainty associated with the licensing process.

And yet, at the same time that we have been cancelling or deferring them, other nations like Japan, France, and Taiwan and Korea have been going pell-mell ahead to build and operate plants, most of which are simply only evolutions of the technology that we developed in this nation.

With strong Congressional leadership, we can remove the institutional impediments to nuclear power. It is prudent and timely to look at that next increment.

It is the judgment of the majority of our industry that the next increment will be the advanced light water reactor, because it affords us the opportunity to build on the experience that we have obtained with over 109 reactors to date throughout this nation.

It is a logical step in the progression. And this is not to take anything away from the importance that needs to be attached to the liquid metal or to the HTGR project. They are important, but we simply see them as further down the line in the overall scheme of things.

Our industry over the past three years has spent close to $13 million on the advanced light water reactor program and you are going to hear more about this program from John Taylor in a few minutes.

I think what is equally important is that we have had financial and technical participation from the Japanese, from The Netherlands, from Korea and Taiwan, all contributing to this effort. So through this collaboration, we will have the basis for something that is really important from a technical standpoint.

In conclusion, we strongly feel that the nation is going to need this additional capacity, both on the coal side and on the nuclear side, partly to accommodate economic expansion and partly to replace some of our aging capacity. And to avoid growing even more dependent on foreign oil, we are going to have to build additional coal and nuclear plants.

It is important to add that, due to the great uncertainties that are presented by the licensing and regulatory process at both the state and federal level, utilities are today unable to predict with any degree of certainty just how much a plant is going to cost, when that plant construction will be completed, and when completed whether or not the plant will be licensed for operation, and finally, whether or not the state regulatory agencies would permit rates to go into effect to reflect the costs of those plants.

Under these circumstances, it is not surprising that many utilities are moving toward plans that are away from ordering new baseload capacity.

Mr. Chairman, your efforts to secure the future of the energy supply of the nation are applauded by the members of our industry, and we thank you for the opportunity to express our views today and urge again the important steps that your Committee and the Congress can take to provide the underpinning and the foundation for the next increments of capacity which are so important to the future of this nation.

Thank you very much.

[The prepared statement of Mr. O'Connor follows:]

Statement of
JAMES J. O'CONNOR

Chairman and Chief Executive Officer
Commonwealth Edison Company

before the

Senate Energy and Natural Resources Committee

United States Senate

on

Advanced Reactors

May 24, 1988

Mr. Chairman, I am James J. O'Connor, Chairman and Chief Executive Officer of Commonwealth Edison Company (CECO). The company I represent, Commonwealth Edison, has twelve operating nuclear units, the largest commitment of any company in the nation. In addition, I serve as Chairman of the Nuclear Power Oversight Committee. I would like to thank the committee for inviting me to express my views on the future of our nation's nuclear energy option and the role a new generation of advanced reactors will play in its future.

I hardly need remind this committee of nuclear energy's importance to this country's economic growth and national security. Our 109 licensed nuclear power plants are the second-largest source of U.S. electricity generation, accounting for 18 percent of our total electric generation.

Nuclear energy has made a substantial contribution to our energy security. Since 1973, the U.S. has invested about $130 billion in nuclear power plants that have displaced the equivalent of about 3.5 billion barrels of imported oil and, in so doing, lowered our trade deficit by $106 billion. Importantly, these plants have generated only a small percentage of the total electricity they will generate in their lifetimes, so this past investment will continue to reap benefits well into the future.

Thus, nuclear energy has contributed significantly to our electrical needs in a safe and reliable manner. However, due to

the uncertainty in the regulatory process, and the large expenditure of resources prior to receiving operating approval, I firmly believe that new nuclear commitments cannot be made by U.S. electric utilities in meeting their near term generating needs.

With that as prologue, I would like to briefly discuss Commonwealth Edison's role as a pioneer in our nation's commercial nuclear energy program. I believe our company provides a unique historical perspective on why the nuclear option is so vital to our nation's future.

We became involved in nuclear power because we wanted to have a diversity of basic energy supply and because we believed in the long-term promise that nuclear power could provide stability in power costs. Once Dresden 1, a General Electric boiling water reactor plant, proved economical, efficient and safe, the company decided to aim for having roughly one-half of our capacity in nuclear plants. We have recently reached that level. The extremely low projected operating expenses, measured by the low cost of uranium fuel compared with coal (Commonwealth's primary fuel), has over time more than off-set the higher capital costs of nuclear power. Moreover, we saw these higher nuclear capital costs virtually as internalized environmental protection costs, since the Company expected to avoid the high and growing costs of waste ash disposal and provide us the opportunity to reduce particulate/sulphur air pollution from our coal plants, old and

new. Dresden 1, the world's first commercial nuclear plant, went into service in 1960. Between February 1965 and June 1966, Commonwealth's President Ayers announced plans to build four more boiling water reactors (BWR) by 1972: Dresden 2 and 3 and Quad-Cities 1 and 2. Each one was to be four times larger than our 180 MW "pilot" plant, Dresden 1. Those plants were built in less than 6 years at an average cost of $154 per kilowatt.

In 1967 Commonwealth Edison announced its plans to build its two Zion units. Unlike the Dresden and Quad Cities plants, the Zion units were to be Westinghouse pressurized water reactors (PWR). This decision was made to provide for a diversity in reactor types.

Anticipating expanded economic growth and the attendant need for additional capacity, in 1970 we announced plans to build two additional GE BWRs at La Salle County. This decision allowed us to draw on the experience at Dresden and Quad Cities which helped significantly in the design of La Salle's operating and maintenance systems.

Finally, in 1971 and 1972 we announced the start of our most aggresive construction project to date, four duplicate units at Byron and Braidwood. These Westinghouse PWRs not only allowed us to benefit from our Zion experience in the design of these units, but also provided tremendous economies in design and purchasing of equipment and construction. The replication of these four

units also proved to be a significant benefit in the licensing process because most of the technical issues concerning the design of the follow-on units had been resolved during construction of Byron-1.

In 1987, nuclear generation provided 66 percent of Commonwealth Edison Company's electricity. Additionally, recent fuel adjustments reflecting the growing percentage of nuclear fuel as part of our total fuel mix have resulted in fuel cost savings to our customers of approximately $180 million. Thus, Commonwealth Edison's commitment to nuclear energy as a major component of our energy mix has proved to be a wise decision for our customers. However, the recent instability in the ratemaking process has not allowed us to recover the costs of the last three units we have placed in operation.

From a national perspective, as we look ahead, recent reports by U.S. Department of Energy (DOE) indicate that our country faces the prospect of a 100 gigawatt gap between planned capacity construction and projected electric demand by the year 2000. For purposes of comparison, 100 gigawatts is more electricity than is currently generated by all of the nuclear plants in the U.S. Given the long lead times in plant construction, our nation must prepare to build additional electric generating capacity.

Meeting these growing needs is vitally important because electricity has become the lifeblood of our economy. Since 1973,

the only energy source that has kept pace with the Gross National Product (GNP) is electricity. We expect this trend to continue.

The simple fact is that the U.S. economy, like all industrialized nations, is steadily becoming more electricity-intensive. Manufacturers are choosing electricity because it reduces their costs by providing more stable prices, improves their productivity and enhances their control over product quality. For example, in steelmaking, the use of electric arc furnaces is up almost 70 percent in the last 10 years and electric arc furnaces now account for 37 percent of total U.S. steelmaking capacity. In oil refining, the use of electricity has increased 91 percent per barrel of oil refined in the last 20 years. And there are so many other examples: lasers that cut 10-20 times faster than conventional saws; microwaves that kiln-dry lumber in one day instead of 25; electromagnetic waves that cure rubber in minutes, not hours.

Indeed, if our nation is to enjoy continued economic prosperity, a demand will exist for additional generating capacity. Even with increased efficiency, conservation and contributions by renewables, there are only two major supply alternatives which can fill that need -- coal and nuclear energy. Maintaining the viability of both these options will require, as you have pointed out many times, a strong national energy policy; an energy policy with electricity as a fundamental element and nuclear energy playing an essential role.

With continuing public concern about burning fossil fuels and pending legislation before Congress to address these concerns, government, industry and environmentalists may find themselves in a situation where nuclear energy is clearly a most attractive alternative. However, for a new generation of nuclear power plants to play a significant role in our nation's energy future, Congress and industry must overcome some significant challenges.

First, nuclear power regulation is too unpredictable, too complex and too subject to political manipulation. Five plants are still under construction after 15 years, in large measure because of protracted regulatory delays. Political pressures are keeping Shoreham and Seabrook closed. These plants are ready to operate. They have developed satisfactory emergency plans, and they clearly are needed to meet electricity demand in areas now relying on large amounts of imported oil. These plants stand as symbols of the governmental unpredictability to which nuclear power has been subjected. If local politics are permitted to override the technical judgment and federal authority of the NRC, it's hard to see how electric utilities will again be able to consider nuclear energy as an option for the future increments of generating capacity that economic growth will require.

Such short-sighted manipulation of the regulatory process by local authorities for political purposes clearly is not in the best interest of our nation's security and well-being. Even our

existing plants are threatened as long as such regulatory uncertainties exist.

Second, the cost of nuclear plants must be reduced and made more predictable. This can be achieved in part by standardization and licensing reform, including consolidation of the construction permit and operating license procedures. These changes could lessen the lead-time for operation, thus reducing the financing costs incurred as a result of delays.

Third, progress must continue on the legislative initiatives needed to provide the predictability to keep nuclear energy as a viable energy option for the future. We have come far in this Congress with the great help of your leadership and that of your committee. You helped fashion the arrangement to examine the suitability of a high-level waste site in Nevada and to develop the site if it's suitable. This would resolve the impasse that has delayed progress on implementing the Nuclear Waste Policy Act. Additionally, because of your efforts and those of your committee, the Senate passed legislation to restructure our uranium enrichment program and set it on a more business-like footing. Also this year, both the House and Senate overwhelmingly approved a revised and extended version of Price-Anderson, increasing tenfold the public's liability protection in the event of an accident at a nuclear plant. And finally, Congress supported the U.S.-Japan nuclear cooperation agreement.

Finally, all of these uncertainties make it impossible to plan future electric power capacity. This discourages utilities from many responsible long-term decisions and from starting any large investment. A sort of "backdoor deregulation" is underway in the electricity business: utilities are obliged to purchase power from small-scale producers and cogenerators, even though those producers are not required to provide any guarantees of their future contributions to the utility's system. Because of how the regulatory and licensing process has run amok, many states, including my own, have proposed disallowances of large portions of nuclear plant costs from utilities' rates, which in turn serves to discourage any long-term, high-capital-cost baseload plants.

As you know, every nuclear plant ordered after 1973 has been cancelled or deferred. These cancellations have happened for a variety of reasons including the decline in electricty growth in the middle and late 70's, the unpredictability of the licensing process, and the financial burdens that resulted from delays. By 1992, all nuclear plant construction in the United States will be completed. Yet other countries - like Japan, Korea, France and Great Britian - are ordering - and will surely build and operate more nuclear plants, almost all of which are next-step evolutions and developments stemming from U.S. light-water reactor technology.

With strong congressional leadership, the institutional impediments to the future development of nuclear power in our country can be removed. It is prudent and timely to look toward the next generation of nuclear power plants and I applaud the committee for its foresight.

It is my judgment and that of the majority in the nuclear power industry that the light-water reactor (LWR) will remain the dominant nuclear power technology over the next several decades. Over 25 years of favorable operating experience worldwide, along with extensive development and testing programs, support the LWR and provide a sound basis for confidence in this technology. As you pointed out in your speech to Americans for Energy Independence, "there is nothing to hint that light-water reactors are not the safest form of energy known to man." Thus, we expect that an improved version of the LWR will be the preferred choice for the next increment of nuclear capacity ordered in the U.S. This is because, much like the Commonwealth Edison experience with the follow-on units to Quad Cities and Zion, utilities that would be willing to build additional capacity will feel confident building on the extensive operating experience and familiarity with and knowledge of the current LWR, especially as it incorporates state of the art technological improvements. It would be unrealistic to look for a utility to order, in the near future, a reactor based on a technology that has yet to be proven commercially viable, when an advanced version of a technology proven and accepted world-wide will be available.

To this end, a major program has been undertaken in the past several years to develop an advanced light-water reactor (ALWR) for deployment as this next increment of nuclear power generation capacity. This program, supported by the utilities, vendors, DOE, and EPRI has shown exceptional promise in providing standardized advanced LWR designs. The new ALWR will be much simpler than existing plants and will be of modular design to permit predictable and rapid construction.

To meet the needs of this advanced light-water reactor development, the utility industry has committed over $12.6 million of its own funds over the past three years through EPRI's advanced light-water reactor (ALWR) program. You will hear more on this program this morning from John Taylor. In addition to substantial DOE participation, the financial and technical support of utilities in Japan, the Netherlands, Taiwan, and Korea are contributing to this effort. As an industry we intend to keep our commitment to the development of the ALWR.

I also want to voice my strong support for the continued development and funding of other advanced nuclear generation technologies, notably gas-cooled and liquid metal. I believe each will play a unique role in rounding out the full potential of nuclear energy in our long-term energy future. Because of the magnitude of this investment and the lengthy and uncertain time before one can expect a need and therefore a commercial order,

responsibility for the development of these more advanced systems should continue to rest primarily with the Federal government.

In conclusion, our country is going to need additional electric generating capacity in order to continue our economic expansion and replace aging capacity. To avoid growing even more dependent on foreign oil, additional nuclear and coal plants will have to be built. Standardization and licensing reform are essential in encouraging future advanced nuclear plant orders.

It is important to emphasize that, due to the great uncertainties presented by the licensing and regulatory process at both the federal and state level, utilities are unable to predict how much a nuclear plant will cost, when plant construction will be complete, and when completed whether the plant will be licensed for operation and rates included to cover the cost of construction. Under these circumstances, it is not surprising that utilities are not moving toward plans for ordering additional nuclear power plants, or other large based-load capacity of any kind. It would be imprudent for utilities to commit the huge investments required for a new generation of nuclear plant until they have the assurance that the Federal government has a national energy policy that includes electricity as a fundamental element, and a predictable and stable nuclear regulatory system incorporating standardization and a consolidated construction permit and operating license process.

Mr. Chairman, your efforts to assure the future of the nuclear energy option and the development of future generations of nuclear power plants are to be commended.

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ADVANCED REACTOR CORPORATION
P.O. BOX 767, CHICAGO, ILLINOIS 60690

September 14, 1987

Messrs. Wallace B. Behnke
Sol Burstein
Kent F. Hansen
Larry Hobart
John J. Kearney
Lawrence T. Papay
John J. Taylor
Richard F. Walker

Gentlemen:

Thank you for your excellent analysis and thoughtful recommendations concerning the U.S. Department of Energy's advanced nuclear reactor research and development plan. At its meeting on September 10, 1987, the Board of Directors accepted and enthusiastically endorsed your report and authorized me to forward it to the Assistant Secretary for Nuclear Energy. A copy of my letter to Mr. James W. Vaughan is enclosed. You have performed an important service by developing a position on this matter which has the broad endorsement of our industry and serves as a basis for articulating its views to the Administration and Congress.

Sincerely,

James J. O'Connor
Chairman

Enclosure

ADVANCED REACTOR CORPORATION
P.O. BOX 767, CHICAGO, ILLINOIS 60690

September 11, 1987

Honorable James W. Vaughan, Jr.
Acting Assistant Secretary for
Nuclear Energy
U. S. Department of Energy
Washington, D. C. 10585

Dear Mr. Vaughan:

This is in response to your May 14, 1987 letter to Wallace B. Behnke asking for comments from the Advanced Reactor Corporation concerning the Department of Energy's advanced reactor research and development activities. Enclosed is a report prepared by an Ad Hoc Committee, which I appointed to assemble our industry's views on the Department's plan. The report was accepted and endorsed by our Board of Directors on September 10, 1987. The Board authorized me to forward the report to you and urge that the Department's plan be modified as recommended in the report. Moreover, I also have been authorized to commit the Corporation's endorsement of the Plan it modified to reflect the recommendations contained in our report and indicate our willingness to urge Congress to appropriate the necessary funding.

We would be pleased to discuss the report with you at your convenience.

Sincerely,

James J. O'Connor

James J. O'Connor
Chairman

bcc: Honorable Harris W. Fawell
Dr. Alan Schreisheim
Advanced Reactor Board
Ad Hoc Committee

Report of the Advanced Reactor Corporation Ad Hoc Committee For Review of the DOE Advanced Reactor Plan

Introduction

The Advanced Reactor Corporation (ARC) has been asked by DOE (Reference 1) to review and comment on the present DOE plan for the development of advanced reactors for civilian use. An ad hoc Committee has been appointed by James O'Connor, Chairman of the ARC Board to perform this review. The ad hoc Committee's charge and membership is provided in Attachment A. The primary material utilized in the Committee's review is itemized in Attachment B.

The Committee has reviewed the DOE program plan for advanced reactor R&D, by relying in part on the recent report by the Energy Research Advisory Board Panel on Civilian Reactor Development (Reference 2) with its review of the Agency's program plan. The Committee has had the benefit of further correspondence and discussion with DOE officials concerning possible modifications to the current plan. The Committee also solicited input from the major industrial and national laboratory participants in the program.

Current Realities

The growth in demand for electrical energy in the United States has, on the average for the past decade, been less than half that recorded over many previous decades and has resulted in more load generation capacity than currently needed to assure reliable service. There are significant regional differences in demand-capacity match, but the general need for additional increments of generating capacity is projected to occur in the mid-1990s. Given the lead times involved, initial planning for new generation construction should begin soon.

The combination of reduced electricity demand, cost overruns on nuclear generation plants, and the presence of more generating capacity than needed for system reliability has, over the past several years, resulted in considerable consumer resistance to raising electric rates to cover the cost of newly completed generating facilities.

As things stand now, utility capacity planning is based on coal, oil, and gas because of the uncertainty and high cost ascribed to nuclear capacity additions in the current regulatory environment. However, reliance on these primary resources to meet future needs is not in the best national interest, particularly because of the volatility of oil and gas prices and the uncertain availability of oil. The U.S. electric utilities remain convinced that nuclear power will be needed to assure the nation of an adequate supply of electric power at reasonable prices. The CEO Report on Nuclear Power (Reference 3) urges that "the United States should begin now to take steps that will again make nuclear power an option that utilities can prudently consider to meet future needs for electric generating capacity." Changes in the present institutional arrangements governing nuclear power are cited in the report as necessary to restore nuclear power as a viable option, a need which has been reinforced in the Report of the ERAB Panel (Reference 2).

Although these regulatory, financial, and legislative reforms are essential, improved nuclear plant performance and other remedial steps are also prerequisites to expand use of nuclear power in the U.S. About $500 million annually is being spent by the utility industry to increase availability and improve the effectiveness of operations and maintenance of all existing U.S. nuclear power plants to the levels of performance already being achieved in the best performing nuclear plants in the United States. These actions emphasize safety and dedication to excellence in all elements of nuclear power plant operations.

Other prerequisites include the cleanup of TMI-2, the adoption by NRC of a realistic source term with commensurate realistic emergency planning provisions, substantial progress in implementation of the government's responsibility for radioactive waste management, and an effective enrichment supply policy. Industry is contributing an additional $500 million annually to these activities.

The Next Increment of Nuclear Capacity

Achievement of the above objectives is expected to increase confidence in the safety, reliability, and economic superiority of existing U.S. nuclear power plants to where the nation's electric utilities can prudently include nuclear power in their capacity planning. Once the institutional reforms are implemented and their effectiveness generally accepted, confidence will be restored in the processes to build and operate new nuclear plants. The question then becomes, what reactor concept will be embodied in the next generation of nuclear power plants?

It is the present judgment of the majority in the nuclear power industry that the light water reactor (LWR) will remain the dominant nuclear power technology for the next several decades. Over 25 years of favorable operating experience worldwide, along with extensive development and testing programs, support the LWR and provide a sound basis for confidence in this concept. Thus, an improved version of the LWR is expected to be the preferred choice for the next increment of nuclear capacity ordered in the U.S.

Advanced LWR Development

The Advanced LWR Program, presently being funded jointly by industry and DOE, offers the most promising approach to developing the next generation of nuclear power plants. A full

discussion of this program is contained in the ERAB Panel Report and hence nothing more need be said here beyond confirming the importance of this effort in defining a substantially improved LWR and in bringing a greater level of standardization to nuclear power plant designs in the United States. The focus of discussion in this report will be on the development of advanced reactor systems which offer the prospect of superior economics in the resource environment of the next century.

Advanced Reactor R&D as an Element of National Energy Policy

The committee agrees with the ERAB Panel that on a matter as important as energy supply, the nation should have a high confidence strategy which provides consistent support of mission-oriented research and development on energy conversion systems that make more efficient use of our indigenous energy resources. The Federal Government's role in this R&D should be to: (i) identify new technologies and enhancements of existing technologies which offer long-run potential for superior economics, reduced environmental impact, and more passive safety features, (ii) conduct R&D necessary to bring the most promising of these technologies to where they can be developed and marketed with private capital, and (iii) facilitate the transfer of these technologies to the private sector so as to foster development of an industrial capability to deploy them in the nation's energy economy on a timely basis to the overall benefit of the public.

The committee views with alarm the departure from consistent support of energy R&D beginning in the mid-1970s. Although the problem is widespread, nowhere has this been so acute as in the field of civilian nuclear power. Nuclear reactor technology differs from other large-scale energy conversion systems in ways that dictate special treatment at the federal level. For one thing, consideration of public health and safety call for federal regulations of nuclear power plant design, construction, and operation. The potential for diversion of special nuclear

materials into military or even clandestine activities demands international oversight by an agency, such as the International Atomic Energy Agency (IAEA). Finally, the potential for nuclear power to bring about a material reduction in our dependence on foreign oil without undue environmental insult affords it a unique national policy role. Thus, further erosion of U.S. leadership in advanced nuclear reactor research and development (R&D) will seriously undermine long-term economic and strategic national policy objectives.

The current Department of Energy (DOE) advanced reactor program is in danger of being totally eviscerated by cutbacks in government funding of this important work. In our opinion, pursuit of this course of action would be a serious and irrevocable mistake. Meaningful research simply cannot be conducted in an environment of on-again, off-again funding. The lack of continuity will cause the technical talent now engaged in carrying out this research to be disbanded and lost for future work. This nation's investment in nuclear power is too great, its past and future contributions to U.S. competitiveness in world markets too significant to allow liquidation of four decades of advanced reactor R&D by default. Billions of dollars of consumer savings in addition to billions of dollars of export sales and thousands of high technology jobs for U.S. workers are at stake. By dropping out of the vanguard of advanced reactor R&D, the U.S. will be giving up to its international competitors and undermining its strategic position with respect to both dependence on foreign oil and international nonproliferation initiatives.

Candidate Technologies for Development

There are two advanced reactor concepts that are regarded as candidates for further development. These are the liquid metal reactor (LMR) and the high temperature gas-cooled reactor (HTGR). The technical feasibility of both has been demonstrated here and overseas. Both have excellent passive safety

characteristics and are suitable for the generation of electric power, but are not yet known to be economically competitive. The innovative efforts of the past several years have given promise that economic competitiveness can eventually be achieved by both HTGR and LMR with coal-fired and LWR generation at current fuel prices. DOE has therefore established economic competitiveness as a major goal for those two advanced reactor development programs. If this goal is achieved, these systems could be deployed commercially early in the next century. Then, as increased reliance on lower grade uranium resources forces prices upward, in 2030-50 time range, the LMR could become increasingly attractive as a power producer because of its vastly superior fuel utilization efficiency, especially when used as a breeder. Similarly, as fossil fuels prices rise, the HTGR, with its high operating temperatures, could become increasingly attractive as a source of industrial process heat in the mid-range of the next century, enlarging greatly the use of nuclear power as a substitute for fossil fuels.

Several major developments have emerged recently from DOE's ongoing R&D program activities. The new conceptual designs to both the LMR and HTGR incorporate additional passive safety characteristics which reduce, and in some cases eliminate, the need for engineered safeguards equipment or emergency operator response, greatly reducing the chances and consequences of a severe accident.

Two areas of research show promise for improving significantly the fuel cycle economics of the LMR. One being developed by Argonne National Laboratory employs a new metal alloy fuel in combination with a unique pyroelectrolytic fuel reprocessing technology to be tested at DOE's Experimental Breeder Reactor II (EBR-II). The other is a once-through fueling concept involving development of an ultra-long life uranium oxide core at the Hanford Engineering Development Laboratory, which is being tested in DOE's Fast Flux Test Facility (FFTF). This unique fuel cycle R&D is not currently being pursued overseas.

Significant potential has also been demonstrated for improving the economics of both the LMR and the HTGR through such innovative engineering approaches as: modular designs, improved materials, natural circulation cool-down, greater automation, and shop fabrication of large components.

As things stand now, the U.S. lags behind France, the Soviet Union, and the United Kingdom in construction and operation of large LMR plants. Japan and the Federal Republic of Germany are moving aggressively into competitive positions with construction of large LMR demonstration plants.

The Federal Republic of Germany is now approximately on par with the U.S. in development of HTGR technology, having recently completed a demonstration reactor of a size comparable to Fort St. Vrain, and the Soviet Union and Japan are pursuing development programs moving toward plant deployment.

DOE Advanced Reactor Development Program

Funding of DOE's program has been reduced over the past five years from well over $600 million annually to a budget proposal of about $200 million this year. The committee regards $200 million as the minimum level needed to sustain a viable advanced reactor R&D effort.

The DOE's advanced reactor R&D program (Reference 4) has as its primary goal the development of the LMR. Efforts are aimed at achieving technological breakthroughs and design innovations which have potential to significantly accelerate the prospect for economic parity with, or superiority to, existing technology. The centerpiece of the DOE program is Argonne's metal alloy fuel and pyroelectrolytic process for recycling the reactor's spent fuel. The DOE's oxide fuel development program has been scaled down and further development of oxide fuel reprocessing and

fabrication has been terminated. The engineering development segment of the DOE program has been focused on modular configurations with passive safety features, in capacities ranging from 140 to 350 MWe.

A DOE plan calls for completing detailed design of a prototype advanced LMR system so that construction can begin on a prototype plant as early as the mid-1990s.

The development of HTGR technology in the U.S. was dominated by the private sector and focused on plant deployment until the collapse of the commercial nuclear market in the mid-1970s. Over the past decade, DOE has also been sustaining development of the high temperature gas-cooled reactor (HTGR) in recognition of its long-range potential as a source of high temperature heat for industry processes as well as an alternative to the LWR for electric power generation. The goal of the HTGR program is to achieve competitive economics through the use of an innovative modular design with a reactor module power output of approximately 140MWe. Utility/user support is currently organized through Gas-Cooled Reactor Associates, with supplemental technical support by EPRI. The present DOE plan is to reduce the government's effort to a closeout level in preparation for phasing it out entirely in the next couple of years.

DOE's advanced reactor program has involved limited exchanges of technical information with countries overseas who are conducting advanced reactor development programs. Although the European community has banded together in a shared R&D program on the LMR system, the U.S. LMR program is still essentially independent of these and other efforts overseas.

Comments on the DOE Program

In the committee's judgment, the DOE's Advanced Nuclear Reactor R&D Program should be better synchronized with the market

realities described earlier in this report. Since the LWR will be the dominant reactor technology for the next several decades, it is premature to begin design and construction of large scale demonstration facilities based on current advanced reactor technology. The inevitable delays that would occur in starting a demonstration plant design prior to resolution of all of the key issues would undercut the central objective of the demonstration plant, namely to lend confidence to the economics and technical performance of the design. Rather, this effort should be deferred, and the resources concentrated on research in areas with promise for technical breakthroughs which will lead to quantum improvements in economics while continuing to enhance passive safety capability. A mechanism is needed to sustain a viable yet affordable engineering development effort over several decades that provides programmatic focus and vigorous interaction with the R&D segment of the program, involves the private sector and can be expanded into an industrial capability as a market develops for one or more of these technologies.

The objectives of this effort should include establishing the desirable characteristics and features of the design, identifying innovative cost-saving approaches and assessing the economics of the plant, making decisions on safety approach and holding associated dialog with NRC, and guiding the R&D activity. The design activity should include a study relative to the size of the plant and the degree to which modular concepts should be employed. At the same time, the U.S. should expand its collaboration overseas with those countries constructing and operating large scale LMR and HTGR demonstration facilities. Jointly planned and shared international LMR and HTGR development programs could provide the U.S. with essential practical design construction and operating experience from overseas demonstration plants while affording our international partners the fruits of the more advanced fuels and materials research underway in the U.S.

There has been a substantial redirection of the DOE program over the past several years, much of which is in accord with the ERAB Panel recommendations. Nevertheless, the plan still fails to come to grips fully with the current realities. We find three basic problems with the present formulation:

1. It relies on detailed design of a LMR demonstration facility which could be constructed in the U.S. in the 1990s but which is generally regarded as premature and thus unlikely to attract major financial support from the private sector.

2. It prematurely forecloses further research on alternative LMR fuel cycles and the development of the modular LMR and HTGR concepts or other innovative advanced reactor designs which could take advantage of emerging technology.

3. It places insufficient emphasis on international collaboration as a means of providing meaningful feedback of plant experience in the absence of a U.S. project.

In discussions with DOE personnel and through review of new draft DOE programmatic materials, we have been led to believe that consideration is being given to redirecting the Agency's program as follows:

1. Eliminate explicit scheduling of construction of an LMR demonstration project within the present planning horizon. This would eliminate a $50 million increase in annual budget.

2. Undertake a vigorous drive to engage in shared LMR development overseas, particularly with Japan.

These changes address some of our concerns with the earlier program plan; however, there are other aspects which need to be corrected.

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The enclosures to Dr. Rossin's May 14 letter (Reference 1) indicate a winnowing down of alternates, which, although ultimately appropriate, is scheduled to occur sooner than the committee judges desirable and that the ERAB Panel recommended. We are concerned that premature elimination of viable alternatives will discourage innovation and foreclose opportunities for technological breakthrough.

The programs should be concentrated on achieving two primary goals:

1. economic competitiveness with alternate conventional generation, (coal and LWR plants), without assuming a rapid acceleration of fuel costs for these conventional plants, and

2. major improvement in passive safety features.

When confidence is established that these goals can be met, the programs should focus on bringing the technologies to technical readiness with adequate regulatory review and experimental verifications so that a demonstration could be planned with confidence. The engineering development, and the design work required to define its implications, should be integrated with the scientific and technical R&D programs to assure this technical readiness. Schedules, milestones, success and failure criteria, and organizational arrangements should be defined to establish this integrated approach.

We believe, as does the ERAB Panel Report, that retrenchment of the long-life oxide core R&D work is premature in view of the limited amount of experimental data accumulated to date on the performance of the reference metal fuel alloy in the extended burn-up region. Oxide fuel has been a highly successful portion of the LMR development program to date and one which promises additional unique performance capability. In addition to being identified by DOE as the back-up fuel for the LMR, oxide fuel is

the reference fuel adopted by most other countries. Curtailment of U.S. research in this area will deny the U.S. important data it could otherwise contribute to collaborative international exchanges.

The committee joins the ERAB Panel in endorsing continuation of the R&D on metal alloy fuel and pyroelectrolytic reprocessing, at least through engineering scale system testing at EBR-II. Centering this project at EBR-II provides a unique opportunity to integrate these innovations into an operating electric generating facility. As we assess the situation, this program, the ultra-long life core, and the modular LMR and HTGR concepts, are potentially the most significant advanced reactor developments of the decade anywhere in the world.

The committee is prepared to endorse DOE's plan to replace the two modular LMR design efforts with a single follow-on engineering design segment if the effort is organized so as to encourage innovation, provide the necessary feedback of engineering requirements to the research segment of the program, facilitate transfer of technology to the private sector and encourage development of an industrial capability on a timely basis.

Even if all the initiatives discussed above are pursued, there is still a gap in the program which cannot be fully covered through overseas collaboration: in depth testing to support the MHTGR design program and LMR component development, particularly to prove out a reliable steam generator for the LMR. Significant planning has been underway to implement such test programs with a combination of private investment, commercial revenue, and government funding. These plans would envision a MHTGR test facility, probably at the Idaho National Engineering Laboratory, a steam generator proof test on the FFTF at Hanford, and continuing LMR component testing in the ETEC facility at Santa Susanna. DOE should encourage these efforts.

With regard to the HTGR, the committee believes that the DOE's decision to close out government funding of the modular HTGR development is wrong. As a result, the U.S. will be forced to rely solely on overseas programs, principally in the Federal Republic of Germany, for information about and development of this technology, but without any U.S. supplier and technology base. Instead, a collaborative program is recommended with U.S. industry, supported by DOE development funding, and international partners, such as West Germany and Japan.

The MHTGR licensing process introduces major uncertainties into deployment which preclude major private financial participation in the MTGR in the current environment. Reduction of regulatory uncertainty will require extended interaction with the NRC involving detailed review of the design characteristics and development of remaining experimental data required to support the review. Thus it is essential that DOE continue to support the MHTGR until the regulatory uncertainty can be adequately reduced.

DOE's Role in Program Implementation

The Committee sees DOE's role in implementing this advanced reactor development program as follows: DOE's primary objective should be to develop concepts with a high potential for economic and passive safety breakthroughs. A sufficient level of technical depth with adequate regulatory review and experimental verification should be achieved so that decisions for detailed engineering development and demonstration can be made with confidence when market conditions indicate the need. If market conditions in another country stimulate a decision of this nature sooner than in the United States, it would be appropriate for DOE and U.S. industry to participate. Because of this latter possibility, it is important that DOE promote a shared international program, establishing an appropriate strategic plan, schedules and milestones. Negotiation and implementation of this

international program should be done with a line management organization rather than a part-time staff activity as has been the case in the past.

DOE's role as overall manager of the development program should be at the systems and integration level. Collaboration among DOE, the national laboratories, and private industry is particularly important. The present collaborative effort on the Advanced LWR program is a model to be emulated.

The Need for Stabilization

The committee joins with the ERAB Panel in urging that funding of the advanced reactor program be stabilized at a level that will assure the ongoing viability of the entire program. The current proposed fiscal year 1987 level of about $200 million annually is a bare minimum level of funding. A substantial portion of that funding is needed to operate the LMR test facilities which are vital to a realistic LMR domestic program and effective international collaboration. It is questionable whether the remaining funds are minimally sufficient to sustain the research and innovative design elements of the program.

Evaluation of past successes in industrial development has clearly shown that a long, persistent and stable development effort is a necessary element of success. Energy competitiveness in price and technology is at stake. Foreign examples, such as France and Japan, demonstrate that creative nuclear development can be enhanced when a long-term stable national nuclear policy is in place. We note that both countries have well-developed programs for the future which place them in an advantageous position for future competitiveness on the world market. Events of the past 15 years have demonstrated that the energy sector once considered stable is, in fact, quite fragile. If the U.S. wishes to regain its industrial competitiveness, it must take seriously the lessons to be learned from the past and develop a stable national policy regarding nuclear power development.

DOE Contractor, National Lab Up-dates

The Committee reviewed the up-dates from the ERAB Panel submissions of the major contractors and national labs engaged in the DOE advanced reactor development programs. The recent progress which has occurred is impressive and substantiates the importance of continuing these innovative programs.

There was a reasonable concensus of support of the DOE program among the respondents except on two issues: (1) the speed of selecting a single concept for concentrated effort and (2) the timing of a demonstration plant to prove out that concept. The Committee's position falls within the spread of opinion on these two issues.

Conclusion

The committee believes that expanded use of nuclear power will be necessary to assure the nation of adequate supplies of electricity at reasonable prices in the next century. In its opinion, the light water reactor will be the dominant nuclear technology for electric power production for the next several decades and thereafter the nation's energy economy will demand economically superior advanced reactor systems that will produce energy more reliably and at a lower cost than the alternatives in the then current fuel cost environment of the next century.

The committee concludes that the DOE advanced reactor R&D program, if amended as we suggest, will reflect the current realities and take advantage of the window of opportunity afforded by the slowdown in LWR deployment by focusing on areas of research that offer the possibility for technological breakthroughs. This research focus in combination with innovative designs with potential for significant improvement in economics and enhanced passive safety has the best prospect for success.

The committee offers the following conclusions and recommendations concerning the DOE advanced reactor R&D program:

1. The DOE program fails to come to grips fully with the current realities. With the recommendations that follow, the program will be responsive to the nation's long-term energy needs and is an appropriate undertaking for the Federal government.

2. The Advanced Light Water Reactor (ALWR) Program presently being funded jointly by industry and DOE offers the most promising approach to developing the next generation of nuclear plants to be deployed and should be continued.

3. Continuing R&D on the LMR concept incorporating the metal fuel cycle with pyroelectrolytic reprocessing is appropriate and should be centered at EBR-II, but the program plan to eliminate further R&D on ultra long-life oxide fuel is premature. The oxide research should be continued at least until the operating and economic superiority of the metal fuel cycle has been experimentally confirmed.

4. Plans for a large scale LMR demonstration plant should be eliminated from the program schedule, the funds directed toward relevant research with suitable arrangements for the two LMR innovative design studies to be merged into a follow-on engineering design effort centered at a national laboratory with appropriate participation by reactor manufacturers, architect-engineers, universities and electric utilities. This effort should take full advantage of the Stevenson-Wydler Act as amended to affect transfer of the technology to the private sector and encourage development of an industrial capability on a timely basis.

5. The government should continue to fund the modular HTGR design, licensing and technology development with the

expectation that private sector interests will assume increasing responsibility for introducing the reactor concept into the nation's energy economy.

6. A more vigorous effort should be made toward collaboration with other nations involved in advanced reactor demonstration facilities.

7. It is important that in the absence of a specific demonstration plant, the programs be given the clearly understood mission of bringing the technologies to the point of technical readiness for a demonstration or prototype plant.

8. For the near term, the Federal government should allocate at least $200 million annually to advanced reactor R&D. This is a minimal level and will require increased international collaboration to sustain a viable advanced reactor development program until market forces are established that will provide the basis for increased funding and deployment.

The committee further recommends that the Advanced Reactor Corporation urge DOE to modify their program as we are recommending, and if this is done, we further recommend that ARC endorse the DOE revised program and urge Congress to appropriate the necessary funding.

JJT:3260AD7c

Attachment A

ADVANCED REACTOR CORPORATION
P.O. BOX 767, CHICAGO, ILLINOIS 60690

May 26, 1987

Messrs. Bob Bergland
William B. Ellis
Robert M. Ginn
Andrew H. Hines, Jr.
Larry Hobart
William G. Kuhns
William S. Lee
Donald W. Mazur
Walter J. McCarthy
William McCullam, Jr.
Paul W. Murrill
Robert H. Short
F. F. Stacy
John J. Taylor
Richard F. Walker
William F. Willis

Gentlemen:

As you may recall, we have an agreement with the Department of Energy under which we have consented to advise the Agency on matters relating to research and development of advanced reactors for the production of electric power. Dr. A. David Rossin, Assistant Secretary for Nuclear Energy has asked us for our views concerning their current program plans. A copy of his letter is attached.

I have asked John Taylor to head an ad hoc committee to develop a response for your consideration. Others who I am asking to serve on the Committee are Wallace Behnke (CWE), Sol Burstein (WEPCO), Larry Hobart, Kent Hansen (MIT), Jack Kearney (EEI), Larry Papay (SCE) and Richard F. Walker.

Please call me if you have any comments or suggestions.

Sincerely,

James J. O'Connor
Chairman

cc: W. Behnke
S. Burstein
K. Hansen
J. Kearney
L. Papay

Attachment B

Primary Review Material References

1. Assistant Secretary Rossin's letter to Wallace Behnke of May 14, 1987, requesting the ARC review and enclosing programmatic material on LMR development.

2. The Summary Report of the ERAB Panel on Civilian Reactor Development

3. Report of the CEO Task Force on Nuclear Power, Edison Electric Institute, February, 1985.

4. Draft programmatic material provided by DOE at meetings with utility representatives on April 1 and May 7, 1987.

STATUS REPORT ON
UTILITY RESEARCH ON NUCLEAR POWER

by

Sherwood H. Smith, Jr.
Chairman, President and Chief Executive Officer
Carolina Power and Light Company

before the

U. S. Nuclear Regulatory Commission

May 4, 1988

In Conjunction With The

1988 NUCLEAR POWER ASSEMBLY

NRC Briefing:

STATUS REPORT ON UTILITY RESEARCH ON NUCLEAR POWER

By Sherwood H. Smith, Jr.

Good morning. It is a pleasure and privilege to report to you on the electric utility industry's work in nuclear research and development—particularly the R&D efforts of the Electric Power Research Institute. My own company was a founding member of EPRI and I serve on the EPRI Board and Executive Committee and as Chairman of the Strategic Planning Committee.

In the nuclear area, EPRI is one part of a team of utility-sponsored organizations dedicated to safety, reliability and operational excellence. EPRI works closely with both NUMARC (The Nuclear Management and Resources Council) and INPO (the Institute of Nuclear Power Operations). EPRI has collaborated with NUMARC in such areas as erosion-corrosion, decay heat removal, severe accident issues and others. And EPRI has worked closely with INPO on a variety of technical issues—equipment reliability, water chemistry, maintenance, human factors guidelines and in-service inspection, among them.

Let me review briefly some facts about EPRI research. EPRI's utility membership represents over 70 percent of America's generating capacity and over 90 percent of our operating nuclear plants. The utility industry contributes over $360 million to these research efforts; just under 20 percent is dedicated to nuclear power research. The Nuclear Power Division's research budget is augmented by cooperative or co-funded programs, including a number of cooperative programs with the NRC. Currently, about 50 percent of the benefits that accrue to utilities from EPRI research have come from nuclear power division programs.

Safety First. I want to stress EPRI's commitment to a "safety-first" approach when it sets priorities for nuclear energy research. We take a broad view of safety. In our view, it includes both reactor safety and the safety of nuclear plant personnel. Here are just two examples.

After the December 1986 feedwater pipe rupture at Surry, EPRI created a task force and a program on erosion-corrosion in high pressure water (or single-phase) piping, drawing on experts in materials, water chemistry, thermal hydraulics and systems engineering. EPRI sponsored workshops and distributed reports on the technical aspects of the problem, and developed a computer program (called CHEC) to help utilities predict where to look for single-phase erosion-corrosion. EPRI also helped develop a set of NUMARC Working Group recommendations to address this issue, and is now developing a parallel code (called CHECMATE) to predict erosion-corrosion in pipes carrying a mixture of saturated steam and water (or two-phase) fluid.

EPRI research has also helped reduce occupational radiation exposures. You heard Jim O'Connor mention that collective radiation exposure per nuclear unit has dropped 50-60 percent since 1980. EPRI's contribution in this area includes the LOMI decontamination process, improved control over primary water chemistry, automated inspection techniques and the development of new cobalt-free alloys to replace stellite, a major source of cobalt-60 in nuclear plants.

Accident Research. The utility industry assigns a high priority to severe accident research. In the seismic area, for example, EPRI has developed new analytic tools, performed large scale seismic tests, and gathered extensive earthquake survivability data to help resolve concerns about seismic adequacy. This has helped resolve seismic issues involving possible large earthquakes in the eastern U.S.

EPRI's work on severe accidents also includes emergency diesel generator reliability, decay heat removal, the IDCOR program and extensive experimental work on containment integrity.

Reliability. One of our industry's goals is improved reliability and availability and EPRI has several valuable programs in this area. Just a couple of examples:

o EPRI helped develop ways to prevent intergranular stress-corrosion cracking in boiling water reactor recirculation piping, which has caused major outages at BWRs. Through EPRI, the utilities sponsored a nine-year, $90 million program to develop remedies, including crack-resistant materials, new welding procedures, water chemistry guidelines and advanced in-service inspection methods.

o EPRI research has also improved the reliability and availability of steam generators and reduced repair and inspection costs. Between 1980 and 1984, the average annual lost capacity from forced and extended outages and steam generator replacements was 5.7 percent, at an average annual cost of $196 million. In 1985 and 1986, that lost capacity rate was lowered to 1.7 percent, with an average annual cost of $59 million—over a three-fold improvement. This shows how research geared to improved plant reliability has also reduced costs.

Operations and Maintenance. EPRI is helping INPO develop a practical, cost-effective approach to improving industry operations and maintenance practices, building on the programs already in existence at many utilities. The principal focus remains safety and improved reliability. But the need to address the acute problem of escalating O&M costs forced EPRI to re-evaluate the objectives, resource allocation and benefits of maintenance programs in terms of improved safety and reliability. It seems clear that the industry is spending more than enough money on O&M. U.S. O&M costs are among the highest in the world—higher than France, Sweden, and other countries with excellent operations and maintenance. The U.S. industry needs to spend its money more wisely.

To help utilities optimize their maintenance programs, EPRI is working closely with INPO on several initiatives. EPRI's major new maintenance effort is the Nuclear Maintenance Assistance Center, or NMAC. Modeled somewhat after the Nuclear Safety Analysis Center (NSAC), NMAC will provide a vehicle for timely analysis and dissemination of field experience and the transfer of new maintenance technology.

Our aim is to introduce a more effective "learning curve" in all elements of maintenance, not just in key components like steam generators. This rapid review and feedback will result in technical information and practical guidelines for maintenance personnel.

Advanced Reactors. Although institutional factors are the main impediment to nuclear energy's expansion, now is the time to define the technical characteristics of the next generation of nuclear power plants. That is the purpose of the last program I will discuss, the industry's Advanced Light Water Reactor (or ALWR) program.

We are pleased with this program's progress—not least because it places the responsibility of developing the requirements for future nuclear plants squarely where it belongs—in the hands of the utilities. The utilities are accountable for the safety and economic performance of these reactors, and must provide the resources for their construction, operation and maintenance. As a result, EPRI's management of the ALWR program relies heavily on the utility executives that serve on the ALWR Steering Committee.

The ALWR program is a joint effort with the Department of Energy, whose participation and support is vital. DOE also has the primary role in long-range reactor development—the liquid metal cooled and gas cooled systems, in which EPRI plays a modest supporting role. The primary utility focus is on the ALWR.

For the ALWR to be a viable candidate for utility investment, it must meet three fundamental standards. First, it must be an excellent power plant in all respects. This means safety foremost, but it also includes reliability, maintainability and compatibility with the environment. Second, it must be economically attractive compared to fossil-fired units. Finally, the ALWR must provide very high protection of the utility investment in terms of predictable construction costs and schedules, assured licensability, predictable operating and maintenance costs and very low risk of severe accident.

The ALWR program is developing two design concepts to meet these standards. In each case, both pressurized water reactor and boiling water reactor designs are being considered. The two design concepts are an evolutionary plant (1,000 megawatt electrical reference design) and a passive safety plant (600 megawatt electrical reference design).

In the evolutionary ALWR concepts, systems and hardware are conventional, but the designs place increased emphasis on safety, simplicity, increased design margin and improved human factors. For example, a PWR designed to these standards would use a conventional reactor coolant system, but with much improved reactor coolant pump seal designs; steam generators with greater corrosion resistance and a larger secondary side water inventory; and a much larger pressurizer to accommodate a full post-scram transient without actuation of pilot operated relief valves. The reactor manufacturers are developing the detailed designs to be consistent with the utility requirements and are submitting them to NRC for certification.

The second ALWR design option, potentially attractive over the longer term, is the passive plant. The ALWR passive plant increases the use of intrinsic physical characteristics, such as gravity and natural circulation to remove decay heat, provide emergency core cooling and prevent core damage. The incentives for developing the passive plant are substantial. The plant protection systems would substitute intrinsic, or passive, response for the active, engineered safeguards equipment used in existing plants. The passive plant offers greater opportunity than the evolutionary plant to simplify—by reducing the number of valves, pumps, tanks and instruments—with an attendant improvement in safety, construction time and cost, plant operability and maintainability. The passive plant may be more easily licensable than existing plants because of its simplicity, increased safety margins and improved human factors.

We are confident that the ALWR program will yield financially attractive, licensable, standardized systems, ready for construction when they are needed during the next decade. The promise of this program is reflected in the fact that it is being joined, financially and technically, by utilities from Japan, Taiwan, Korea, Italy and the Netherlands.

In closing, let me just say that we appreciate the cooperation of NRC in identifying areas of joint safety research with the industry. We believe such joint projects produce more meaningful results, which are used in a more timely and effective manner, at less cost to both the taxpayer and the ratepayer.

Middle Atlantic States to Face Brownouts This Summer as Electricity Use Increases

By Bill Paul
Staff Reporter of The Wall Street Journal

NEW YORK—Middle Atlantic states are almost certain to be hit with brownouts this summer, electricity-supply specialists predicted.

Large sections of New Jersey, Pennsylvania, Maryland and Delaware will be affected, along with the District of Columbia, they said. Long Island, N.Y., also is in danger.

Marie R. Corio, president of Applied Economic Research Co., a New York-based utility research firm that monitors power supply and demand, said one key problem is the unavailability of Philadelphia Electric Co.'s huge, 2,000 megawatt Peach Bottom nuclear power plant. The Nuclear Regulatory Commission shut down Peach Bottom last year, citing gross mismanagement.

Another problem, Ms. Corio said, is that some 1,200 megawatts of other capacity will be out of service at any given time this summer because of routine power plant maintenance.

Moreover, according to the North American Electric Reliability Council in Princeton, N.J., the industry's supply and demand monitoring organization, the area's summer peak demand is expected to be significantly higher than last year. Electricity demand in the region increased about 6.5% for the first quarter of this year compared with the first quarter of 1987. Average national load growth for the first quarter grew only about 4.8%.

By brownouts—a curtailment of the use of electric power—the specialists mean mostly industrial customers with "interruptible" contracts would be affected first. Then, presumably a utility would call for voluntary consumption cuts by homeowners. Then could follow mandatory consumption cuts in the form of so-called rolling brownouts.

"We're facing the very likely possibility of brownouts" in the Middle Atlantic region this summer, said Eugene Gorzelnik of the Reliability Council. "We are concerned," added Charles Woodward, assistant manager of the council's Middle Atlantic regional body.

John Anderson, head of the Electricity Consumers Resource Council, said he wasn't alarmed at the potential for shortages, but added, "I wouldn't be a bit surprised if industrial firms that usually aren't interrupted during the summer are interrupted by their local utility this year."

Ms. Corio said the Middle Atlantic region can't solve its problem simply by buying more power from other areas of the U.S. She said the utilities in the Middle Atlantic area are already doing a lot of that, and thus the long-distance transmission lines are tied up.

The brownout danger on Long Island is also due to growth and a lack of transmission lines to bring power in from other areas, Ms. Corio said. "It's not a pretty picture out there," she said.

As for the rest of the U.S., Ms. Corio said the Southeast might have problems, but only if it's an extremely hot summer. Meanwhile, South Central states likely will be spared any problems because of a recent economic slowdown in that region, she said.

Lotus Development Corp.

Second-Period Earnings Seen Near 37 to 41 Cents a Share

Robert Schechter, senior vice president of Lotus Development Corp., told analysts that he is comfortable with estimates the company will report earnings of 37 cents to 41 cents a share in the second quarter ending June 30.

In the year-ago second quarter, the Cambridge, Mass.-based software company had net income of $16.3 million, or 36 cents a share, on sales of $94 million.

In a meeting with analysts after the annual meeting in Boston, Mr. Schechter also said Lotus is considering making acquisitions of smaller software companies to improve its position in certain markets, including software for Apple Computer Inc.'s Macintosh computer and the word-processing area. He said the company doesn't plan a stock buy-back.

Lotus common shares closed at $21.50, down 87.5 cents, in national over-the-counter trading yesterday.

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Senator FORD. Thank you very much, Mr. O'Connor.
Mr. Taylor.

STATEMENT OF JOHN J. TAYLOR, VICE PRESIDENT, NUCLEAR POWER, ELECTRIC POWER RESEARCH INSTITUTE

Mr. TAYLOR. We are encouraged by the progress that is being made in the industry's drive for excellence, which will have every plant in this country operating as well as the best ones do today here and overseas. But it is not too early to set goals for development of the new reactor systems which will reopen the option and to press on vigorously with those developments.

The goals are centered around two dominant ones, safety and cost. Although from a public safety perspective, the record of the present light water cooled plants is unmatched, not only avoiding harm to the public but saving many lives each year as compared to other methods of generating electricity, still major advances in safety can be made.

The key to this advance in safety is the human factor, so strongly identified by the Kemeny Commission investigating the Three Mile Island accident. Significant improvements can be made by introducing additional passive safety features into new designs.

Such features reduce reliance on active equipment to respond to an emergency condition, substituting instead additional intrinsic characteristics such as gravity cooling, natural circulation, intrinsic heat sinks, and natural governors which cause reaction rates to slow down when temperature or power speeds up.

Each advanced system—the advanced light water reactor, the liquid metal reactor, and the high temperature gas-cooled reactor—have incorporated such passive safety features. The end result is that operators need not act in hours, but in days, to respond to serious accidental conditions.

And this is the ultimate response to the human factors issue, which makes the training and other aids easier and surer to implement.

The second key goal is cost, being pursued in four major ways: Plant designs will be simpler, making them easier to build, operate, and maintain. The substitution of passive features for active equipment is a major step in such simplification.

The reliability of the plants will be substantially increased so that life cycle costs are kept low.

Modular construction and factory shipyard assembly techniques will be used to reduce both the time and costs of construction.

And standardization will be employed to increase the commonality of engineering, fabrication, and construction operations and regulation. A fundamental step is the standardization of the utility owners requirements, which is well along toward completion in the EPRI-industry-DOE advanced light water reactor program.

Encouraging progress is being made in pursuing these goals in the existing R&D program sponsored by the industry through EPRI and supported by DOE, and the specifics I have given in my testimony. I will not review them with you at this moment.

But what must be done to realize the great potential identified by the work to date? First is the establishment of a stable, appro-

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priately funded R&D program based on a common commitment to achieve goals such as we have discussed.

Second is the need to define the implementing programs with specific milestones, schedules, and success criteria to assure steady, measurable progress toward these goals. Because of the difficulty of financing baseload capacity additions and the existing institutional barriers, there is a window of opportunity to search for technological breakthroughs, to introduce design innovation, and to strive to meet tougher goals.

But this lack of urgency to commercialize the advanced systems must not permit tangential efforts, R&D for the sake of R&D, or pie in the sky concepts which will get in the way of effective progress.

Bitter experience has shown that the hard issues of safety and reliability, predictable cost estimates, environmental adequacy, and licensability must be resolved in the development programs, not during the commercialization phase.

Much has been said about the desirability of a horse race among these advanced reactor technologies, which would give to the winner the prize of being the sole technological candidate for future nuclear power expansion. There are clear benefits from such competition, which have already been revealed from the work to date.

Not the last of these has been the use of innovations originated by one "competitor" in the designs of the others. But it is not clear, in view of the unique features of each concept, that such a selection is appropriate in the long run.

The LWR is an electricity-producing work horse, already proven in many utilities in the U.S. and most overseas, whose advanced versions will make it even more so.

The high temperature gas reactor is a converter reactor that can serve as an industrial heat as well as an electricity producer, which will extend the use of nuclear power to a much broader sector of energy need.

And the liquid metal system is a fuel-producer as well as an electricity producer, which will extend the supply of nuclear fuel for generations.

When a selection is to be made of a concept for introduction into the energy economy, it would be more appropriate that the EPRI-industry-DOE R&D programs provide the technical basis for commercial use and then let the user make the selection.

In the years since the seventies energy crisis, many energy technologies, from synthetic fuels to solar and wind, have been pursued. But the outcome to date leaves us, with the important exception of conservation, where we were then. Coal and nuclear are the only large-scale economical and proven generation options available.

EPRI measures its young life primarily in that time frame. In the words of Dr. Richard Bazhiser, a founding staff member of EPRI and its new President:

"I have spent the last 15 years at EPRI concentrating on the alternatives, from coal to solar. There has been considerable progress, but nothing that would seem to compete with nuclear as it has been deployed in countries such as France and Japan."

The important role of coal has been appropriately recognized by the nation's $5 billion clean coal technology program. As my associate at EPRI, Kurt Yeager, Vice President for Coal Combustion, said here in Washington: "This program could well lead to the innovative rebirth of a coal industry that is currently mired in environmental uncertainty and beset by rising construction and generation costs."

It is equally appropriate to support an equivalent advanced nuclear technology program. These programs might lead to the most important national R&D horse race of the rest of this century.

Like the nuclear technology horse race, it is doubtful that there would be one winner, but that each would be strengthened by the other's activities. The revitalization of these two strong electrical energy sources would make the U.S. and its people the winners, with a significant beneficial impact on the U.S. economy through reliable, low cost electricity, improved U.S. global competitiveness, a decreased trade deficit, and with more assured leadership in global weapons control, safety standards, environmental issues, and finally, reduced vulnerability to oil-gas price shock and supply disruption.

Thank you.

[The prepared statement of Mr. Taylor follows:]

TESTIMONY TO

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

U.S. SENATE

BY

JOHN J. TAYLOR

VICE PRESIDENT, NUCLEAR POWER

ELECTRIC POWER RESEARCH INSTITUTE

PALO ALTO, CALIFORNIA

MAY 24, 1988

I am John J. Taylor, Vice President, Nuclear Power, the Electric Power Research Institute. I thank you for the opportunity to testify on advanced nuclear power R&D.

I would first like to commend the initiative Senator Johnston has expressed to stimulate advanced nuclear power R&D in the U.S. There is a necessary preoccupation with the institutional problems which beset nuclear power which Senator Johnston and his colleagues in both houses have taken constructive action to solve, but it is time that increased attention be given to advancing the technology itself.

You have heard today from Mr. O'Connor of the commitment the industry is making to improve the safety and performance of the more than 100 operating plants in the U.S. Technological contributions to this improvement are important and a substantial R&D program is being funded for that purpose. Submitted herewith for your record is a recent presentation to the NRC Commissioners by Sherwood Smith, Chairman and CEO of Carolina Power & Light, which summarizes that effort.

We believe that this vigorous development effort to raise all U.S. nuclear plants to a high level of excellence is a technical prerequisite to reopening the nuclear option, that is to strengthen confidence in nuclear power so that there is a

national will to move ahead again. Since we are encouraged by the progress being made, it is not too early to set goals for development of the new reactor systems which will reopen the option and to press on vigorously with those developments.

The goals for these new systems are all centered around two dominant ones: safety and cost. Although from a public safety perspective, the record of the present light water cooled plants is unmatched--not only avoiding harm to the public but saving many lives each year as compared with other methods of generating electricity--major advances in safety can still be made. The key to this advance in safety is the human factor, so strongly identified by the Kemeny Commission investigating the Three Mile Island accident as the underlying cause of the accident. The centerpoint of the industry's "drive for excellence" for the country's operating nuclear power plants is the human factor--better training, better procedures, improved control room interfaces, advanced diagnostic aids, human performance improvement guidelines, and maintenance guidelines. But significant improvements can be made by introducing additional passive safety features into new designs. Such features reduce reliance on active equipment to respond to emergency conditions, substituting instead additional intrinsic characteristics such as gravity cooling, natural circulation, intrinsic heat sinks, and natural

"governors" which cause reaction rates to slow down when temperature or power speeds up.

Each advanced system, the advanced light water reactor (ALWR), the liquid metal reactor (LMR), and the high temperature gas cooled reactor (HTGR), has incorporated such passive safety features. Taken to their full extent, the end result is that operators need not act in hours but in days to respond to a serious accidental condition such as a loss of cooling or failure of the reactor shutdown systems. This is the ultimate response to the human factors issue which makes the training and other aids easier and surer to implement.

The second key goal, cost, is being pursued in four major ways:

- The plant designs will be simpler, making them easier to build, operate and maintain. The substitution of passive features for active equipment is a major step in such simplification.

- The reliability of the plants will be substantially increased so that life cycle costs are kept low.

- Modular construction and factory/shipyard assembly techniques will be used to reduce both the time and cost of construction. The advanced systems tend to be of smaller unit output to facilitate these techniques.

- Standardization will be employed to increase the commonality of engineering, fabrication and construction, operations, and regulation. A fundamental step is the standardization of utilities/owners requirements which is well along toward completion in the EPRI/Industry/DOE ALWR Program.

The potential for cost improvement through these measures is sufficiently great that cost goals have been set for all three concepts (ALWR, LMR, and HTGR) that are lower compared with the best conventional LWRs, and with the best coal plants.

Encouraging progress is being made in pursuing these goals in the existing R&D program sponsored by the industry through EPRI and supported by DOE. Evolutionary LWR designs of large (1000-1300 MWe) power output have reached a level of detail so that they are now under certification review by NRC. Conceptual ALWR passive designs of 600 MWe output of both PWR and BWR type have been completed which exemplify the safety and cost characteristics previously discussed. Their gravity

cooling, natural circulation, and reactor stability characteristics have contributed to major simplification: for example, compared to a conventional 600 MWe PWR, only 40% of the valves, 50% of the pumps, and 20% of the cable lengths are required. Detailed assembly and construction development are being carried out with Avondale Shipyards in New Orleans, Louisiana to define specific methods by which major reductions in construction costs can be effected through increased factory fabrication of the passive ALWR.

Two promising conceptual designs of modular LMRs, ranging from 450 to 150 MWe output, have been developed which can utilize either the proven mixed oxide Pu-U oxide fuel, the advanced Pu-U-Zr oxide fuel, or an ultra long-lived mixed oxide core. Both modular designs have the potential for factory fabrication of the nuclear steam supply system. Substantial progress is being made with the Integral Fast Reactor (IFR). The IFR plant uses a co-located metal alloy fuel reprocessing capability which shows promise of a cost breakthrough in reprocessing. All the LMR systems employ the passive safety features demonstrated at EBRII recently which eliminate th[illegible]eed for immediate operator action in accidental conditions such as core overheating and failure of the reactor shutdown systems.

A modular HTGR conceptual design has been completed with power output of 140 MWe which has very effective passive safety characteristics with even less dependence on operator action to cope with the loss of core cooling compared with earlier designs. Major simplification has been achieved in this MHTGR design. The modular design permits full factory fabrication of the nuclear steam supply system.

But what must be done to realize the great potential identified by the work to date? First, as will be discussed by Mr. Landis, is the establishment of a stable, appropriately funded R&D program based on a common commitment to achieve goals such as have just been enumerated. Second is the need to define the implementing programs with specific milestones, schedules, and success criteria to assure steady, measurable progress toward those goals. For most regions of the country, there is not yet an identified urgency to expand nuclear power. Because of the difficulty of financing base load capacity additions and the existing institutional barriers, there is a window of opportunity to search for technology breakthroughs such as those involved in the IFR work at Argonne National Laboratory, to introduce design innovation, and to strive to meet tougher goals. But this lack of urgency to commercialize the advanced systems must not permit tangential efforts, R&D for the sake of R&D, and "pie-in-the-sky" concepts to interfere with the real

progress of preparing for the day commercialization is needed. Bitter experience from the past has shown that the hard issues of safety and reliability, predictable cost estimates, environmental adequacy, and licensability must be resolved in the development programs, not during the commercialization phase. Therefore we must continue to pursue expeditiously resolution of these issues.

Much has been said about the desirability of a "horse race" among these advanced reactor technologies which would give to the winner the prize of being the sole technological candidate for future nuclear power expansion. There are clear benefits from such competition which have already been revealed from the work to date. Not the least of these has been the use of innovations originated by one "competitor" in the designs of the others. But it is not clear, in view of the unique features of each concept, that such a selection is appropriate in the long run: the LWR is an electricity-producing work horse already proven in many utilities in the U.S. and most utilities overseas whose advanced versions will make it even more so; the HTGR is a converter reactor that can serve as an industrial heat, as well as an electricity producer which will extend the use of nuclear power to a much broader sector of energy need; the LMR is a fuel producer as well as an electricity producer which will extend the supply of nuclear fuel for generations.

When a selection is to be made of a concept for introduction into the energy economy, it would be more appropriate that the EPRI/Industry/DOE R&D programs provide the technical basis for commercial use and then let the user make the selection. A clearer definition is needed of the criteria to be met by the R&D program to permit a potential user to make his selection. The "hard issues" of safety, reliability, environmental compatibility, licensability, and predictable lifetime cost certainly must be included in that criteria.

As discussed by Mr. O'Connor, the utilities see the LWR technology as the choice to reopen the nuclear option because they see the melding of the previously discussed advanced features with the past two decades of hard-won experience necessary to assure the detailed aspects of safety and reliability and predictable licensing and construction times and costs. With the recognition of the ultimate potential of the LMR and HTGR systems, they at the same time advocate vigorous DOE support of these developments. These thoughts are described in the Advanced Reactor Corporation report of September 1987 which is hereby submitted for your record.

In the years since the 1970s energy crisis, many energy technologies, from synthetic fuels to solar and wind, have been

pursued. But the outcome to date leaves us, with the important exception of conservation, where we were then: coal and nuclear are the only large-scale, economical, and proven generation options available. EPRI measures its young life primarily in that timeframe. In the words of Dr. Richard Balzhiser, a founding staff member of EPRI and its new President, "I have spent the last fifteen years at EPRI concentrating on the alternatives from coal to solar. There has been considerable progress, but nothing that would seem to compete with nuclear as it has been deployed in countries such as France and Japan."

The important role of coal has been appropriately recognized by the nation's $5 billion Clean Coal Technology Program. As my associate at EPRI, Kurt Yeager, Vice President, Coal Combustion Systems, said here in Washington recently, "This program could well lead to the 'innovative rebirth' of a coal industry that is currently mired in environmental uncertainty and beset by rising construction and generation costs." It is equally appropriate to support an equivalent Advanced Nuclear Technology Program. These programs might lead to the most important national R&D "horse-race" of the rest of the century. Like the nuclear technology "horse-race", it is doubtful that there would be one winner but that each would be strengthened by the other's activities. The revitalization of

these two strong electrical energy sources would make the U.S. and its people the winners: with a significant beneficial impact on the U.S. economy through reliable, low cost electricity, improved U.S. global competitiveness, a decreased trade deficit and with more assured leadership in global weapons control, safety standards, environmental issues, and reduced vulnerability to oil/gas price shock and supply disruption.

Senator FORD. Mr. Landis.

STATEMENT OF JOHN W. LANDIS, SENIOR VICE PRESIDENT AND DIRECTOR, STONE & WEBSTER ENGINEERING CORP.

Mr. LANDIS. Thank you, Senator Ford. I very much appreciate the opportunity to appear here before you and others at the rostrum.

To save time, I would like to just review certain portions of my prepared testimony that do not duplicate what you have already heard. I would, however, appreciate having the entire statement entered into the record.

Senator FORD. All three statements will be included in the record in full.

Mr. LANDIS. First I would like to tell you, all of you on the Committee, how impressed I am by the foresight, judgment, and acumen you have demonstrated so many times during the past year in your initiatives to help resolve the many knotty problems, both institutional and technological, besetting the national nuclear energy program.

If there ever was a technology that cries out for leadership and cooperation among all elements of government, industry, and the consuming public, this is it. I agree with the nuclear critics when they say that resuscitating nuclear power in this country is a supremely difficult job. I do not agree with them when they say that it cannot be done or that it is not worth doing.

By example, this Committee is showing the nation how a tough job must be tackled. The American spirit was not developed by a timorous backing away from either institutional or technological challenges, or by a paranoid desire for absolute safety. It was forged by many decades of resolute effort to meet these challenges in ways that maximize the overall benefits for the nation as a whole.

It seems to me, however, that the United States, despite the valiant efforts of this Committee and others in the federal government, is currently losing some of its determination and ability to meet these challenges successfully.

This is just a personal observation and could be wrong. But I see so much evidence of arbitrary rejection of the use of new technology to help solve our problems that I believe such a trend is developing.

And if anyone is looking for real obstacles to improving the quality of life on this earth, he or she will find it here, that is in our failure to make full and effective use of advanced technology.

We seem to have decided that certain possible technological resolutions to our ills are too risky to explore, even before the solutions have been given a fair trial.

We are closing our eyes to some very high risks, like driving an automobile, because they are commonplace, and at the same time we are holding back the development of new technologies that promise to save thousands, even millions of lives, because apparently we cannot face up to the new risks that they pose, however small they may be.

Fortunately, the people who have succumbed to this comfortable line of thinking are by and large not our leaders, not yet. But they are numerous and influential enough to create much unnecessary delay and confusion in the inexorable march of mankind.

That march, like any, is a dynamic thing that has got to be kept going. Those who stop, falter or stumble cause trouble, not only for themselves but for countless others who follow or depend on them. When the individuals at the head of the line stop, all will be lost.

When I was a teenager, my father was a brakeman on the Lehigh Valley Railroad. He often pointed out to me that, while it was important to be able to stop a train properly—not a very deep conception, but he said it—that it was even more important to be able to keep the train moving properly. Otherwise, why have a railroad?

We need brakemen, but we cannot afford to be a nation of brakemen. We need engineers and firemen, too, to keep us doing what we should be doing to improve our lot.

And that is where I think this Committee is playing a dominant role. That is why I am so encouraged by the determination of this Committee to set up a national advanced reactor development program. You are demonstrating leadership of the highest caliber by running out ahead of this particular high tech field and steering it in the way it must go to survive, not slowing it down, as some very vociferous groups advocate, to a state of atrophy or sterility.

Key industrial executives—and I include in them those that you just heard from today—are demonstrating the same type of leadership. But it is going to take a great multiplication of resolution and talent to turn nuclear power around in this country.

To do that, we need perhaps as high an order of cooperation and dedication as we had in World War Two. And you have heard many reasons, and you have your own good reasons, which you have expressed extremely well, why turning nuclear power around is so important.

Perhaps I could express it in just one other new way. I say it is extremely important because we have got to stop using the atmosphere as an energy sewer. We are tackling that problem in two ways.

You have initiated in Congress a very effective clean coal program. The other way to tackle it is to use a closed-cycle system, which nuclear is. You can control all of the wastes in that system. You do not emit them promiscuously into the atmosphere or the biosphere.

Well, many of my opinions and beliefs regarding the future course of the national advanced reactor development program were shaped and perhaps sharpened by my service as chairman of the civilian nuclear power panel of the DOE energy research advisory board from 1984 to 1986. A copy of that summary report of that panel is appended to this statement, and I would also like to have that entered into the record.

Senator FORD. It will be included.

Mr. LANDIS. I have, after reviewing the results of that deliberation by the panel of the energy research advisory board, on which, I might say, John Taylor also served, come to some conclusions and recommendations that I think are pertinent to what you in this

Committee plan to do with respect to any advanced reactor development act or other legislation that you have in mind.

I would like to suggest that the following provisions be included, and these are very brief, so I will read them to you:

First, a re-affirmation of the need to keep the nuclear power option alive and well;

Second, a definition of the role of nuclear power in future national energy plans;

Third, identification of areas where government and the private sector should work together to resolve, more effectively to resolve important nuclear power issues;

Fourth, organization of Congressional oversight of federally funded nuclear power endeavors. There are too many Subcommittees and too many full Committees of Congress now involved in this operation, and it is very difficult for those of us in industry to figure out who is doing what in Congress.

This Committee I hope will continue to be an exception to that.

Five, establishment of basic funding rules and a stable, adequate funding pattern.

Six, encouragement of cost-sharing by the private sector.

Seven, direction to the Nuclear Regulatory Commission to supply safety advice and independent safety analyses as required by advanced reactor development program. And here I would like to point out that the move that you are making to espouse one step licensing is a very important move to help nuclear power recover.

Finally, authorization of the formation of an executive branch task force or a DOE advisory committee specifically charged with the responsibility to expedite the development and deployment of advanced nuclear power systems. Here I want to ask you to help balance the brakemen in the economy with some driving forces or responsible advocates of innovation and improvement.

Now, the duties of this advisory group might include:

A, the development of the procedures to be followed and the criteria to be used in setting priorities for advanced reactor R&D programs;

B, development of strategic reactor development plans;

C, periodic review of the major reactor development programs under way;

D, periodic review of all collaborative arrangements with other nations to further the development of advanced reactors;

E, coordination of inter-agency efforts to maximize U.S. influence in the international regulation of nuclear power and special nuclear materials;

F, improvement of communications and exchange of data on advanced reactor development among federal agencies and with the private sector;

And finally, investigation of the feasibility of setting up a credible nationwide radiation monitoring system.

I might add just one word in conclusion on that. I have proposed this many times since the energy research advisory board approved that recommendation, and I keep getting questions about the expense involved.

I have checked with a lot of laboratories and nuclear power operators around the nation, and apparently there is already in place

sufficient facilities to form the base for the system. So the expense of enlarging it will not be great.

What is really needed is some good thinking about the units that will be used and how the results would be reported to the public. We have got to develop standardized procedures and standardized units, and they have to be couched in terms that the public will understand and will accept as being well below, in fact extremely far below, the danger level that was experienced even by those close to Chernobyl.

Thank you very much.

[The prepared statement of Mr. Landis follows:]

Presentation

To

Senate Committee on Energy and Natural Resources

By

John W. Landis

Senior Vice President and Director

Stone & Webster Engineering Corporation

May 24, 1988

STONE & WEBSTER

I am John W. Landis, Senior Vice President and Director of Stone & Webster Engineering Corporation. The privilege of appearing before you to present my views on the Federal role in the development of advanced nuclear reactors is very much appreciated. Please understand that these views are not necessarily the official views of Stone & Webster -- although I certainly hope they are reasonably consonant with those of my coworkers -- but are personal observations drawn from over forty years of work in various capacities in the nuclear-power field.

Before embarking on my presentation, I want to tell all of you and particularly your chairman, Senator Bennett Johnston, how impressed I am by the foresight, judgment and acumen this Committee has demonstrated so many times during the past year in its initiatives to help resolve the many knotty problems, both institutional and technical, besetting the national nuclear-power program. If there ever was a technology that cries out for leadership and cooperation among all elements of government, industry and the consuming public, this is it. I agree with the nuclear critics when they say that resuscitating nuclear power in this country is a supremely difficult job. I do not agree with them when they say that it can't be done or that it isn't worth doing. By example, this Committee is showing the nation how a tough job must be tackled.

The American spirit was not developed by timorous backing away from either institutional or technological challenges or by a paranoid desire for absolute safety. It was forged by many decades of resolute effort to meet these challenges in ways that maximize the overall benefits for the nation as a whole.

It seems to me, however, that the United States, despite the valiant efforts of this Committee and others in the Federal Government to stem the tide, is currently losing some of its determination -- and ability -- to meet these challenges successfully. This is just a personal observation and could be wrong, but I see so much evidence of arbitrary rejection of the use of new technology to help solve our problems that I believe such a trend is developing. If anyone is looking for real obstacles to improving the quality of life on this earth, he or she will find one here.

We seem to have decided that certain possible technological solutions to our ills are too risky to explore -- even before these solutions have been given a fair trial. We are closing our eyes to some very high risks, like driving an automobile, because they are commonplace and at the same time we are holding back the development of new technologies that promise to save thousands, even millions, of lives because apparently we cannot face up to the new risks they pose.

Fortunately the people who have succumbed to this comfortable line of thinking are by and large not our leaders -- not yet. But they are numerous and influential enough to create much unnecessary delay and confusion in the inexorable march of mankind. That march, like any, is a dynamic thing. It must be kept going. Those who stop, falter, or stumble cause trouble not only for themselves, but for countless others who follow or depend on them. When the individuals at the head of the line stop, all will be lost.

When I was a teenager my father was a brakeman on the Lehigh Valley Railroad. He often pointed out to me that while it was important to be able to stop a train properly it was even more important to be able to keep the train moving properly. Otherwise, why have a railroad? We need brakemen, but we can't afford to be a nation of brakemen. We need engineers and firemen, too, to keep us doing what we should be doing to improve our lot.

That's why I'm so encouraged by the determination of this Committee to set up a national advanced-reactor-development program. You are demonstrating leadership of the highest calibre by running out ahead of this particular high-tech field and steering it in the way it must go to survive, not slowing it down, as some vociferous groups advocate, to a state of atrophy or sterility.

Key industrial executives, including those you have heard from today, are demonstrating the same type of leadership. But it will take a great multiplication of resolution and talent to turn nuclear power around. To do that we need perhaps as high an order of cooperation and dedication as we had in World War II.

Many of my opinions and beliefs regarding the future course of the national advanced-reactor-development program were shaped and/or sharpened by my service as chairman of the Civilian Nuclear Power Panel of the DOE Energy Research Advisory Board from 1984 to 1986. A copy of the Summary Report of that Panel is appended to this statement, but I would like to take a few minutes to read a number of germane conclusions and recommendations to you.

The Panel doubts that the nation will have adequate long-term security of any type -- military, environmental or economic -- if energy supply is excessively dependent on any one source, particularly foreign oil. There may be periods of a few years' duration when oil, for example, is a glut on the market due to the success of measures such as conservation and the introduction of new sources such as nuclear power, but the inexorable trend in the long run will be significant depletion of domestic oil reserves, substantial increases in prices, and acute aggravation of delivery difficulties. Correspondingly, excessive dependence on coal would incur major economic and environmental penalties, including long-term threats to the stability of the global ecosystem.

Despite the fact that energy does not have a high political priority at present, the Panel believes that DOE must intensify its efforts to keep the overall national energy system strong, flexible and productive. Vigorous action in this regard is particularly important at a time like the present when the public seems to be forgetting the lessons of the past. Nuclear power, as one of the few large-scale options currently available, should have a well-articulated role in federal energy policy. The ERAB report of December 1985 entitled Guidelines for DOE Long-Term Civilian Research and Development included a statement that nuclear-safety and nuclear-waste R&D activities should be "major objectives for the assurance of an adequate supply of economical, safe and environmentally acceptable electric power". The Panel

agrees with this recommendation and points out that since disposal of high-level nuclear waste is solely the responsibility of DOE, the Department's performance in solving the many institutional and technology-application problems involved in the national nuclear-waste program will be as important as, if not more important than, any other factor in determining the extent to which nuclear power is utilized in the future.

As stated in the Foreword, the Panel recognizes that the private sector bears the primary responsibility for the viability of nuclear power. The Panel stresses, however, that some of the crucial problems that must be dealt with, particularly in the areas of reactor safety and disposal of high-level waste, to permit nuclear power to realize its full potential are beyond the ability of industry alone to solve. Substantial government initiative and cooperation are required.

Since the dissolution of the Joint Committee on Atomic Energy, Congressional oversight of energy, and nuclear matters in particular, have been diffused. This, in turn, has created a major drain on resources at the highest levels of both DOE and the Nuclear Regulatory Commission (NRC) because officials are required to cope with a multitude of Congressional inquiries and different emphases and directions. A mechanism to focus Congressional oversight is needed.

The Panel feels that the Strategic National Plan drafted by the DOE nuclear staff does not adequately treat the regulatory

and other institutional problems with which the nuclear industry must contend, particularly the problems arising from public concern about nuclear operations. The plan is also deficient in that it does not clearly indicate the procedures to be followed and the criteria to be used in setting priorities for advanced-reactor R&D programs.

Given the importance of adequate supplies of competitively-priced clean energy to the nation's future economic and strategic wellbeing, the Panel believes that DOE should be committing at least $200 million annually to its base programs for development of advanced reactors for civilian use. Its advanced-reactor-development plans should be revised to reflect current projections of economic parity with LWR technology and should focus on areas of potential economic breakthrough where commercial application is too distant in time, too uncertain, and/or too broad to attract venture capital.

To assure the most effective use of resources and a well-focused effort, major tasks in each development area should be sharply defined, with schedules, milestones, and success/failure criteria established to permit further winnowing of the alternatives to those with the greatest promise.

The Panel also recommends that additional collaborative agreements with those nations that have active LMR and HTGR demonstration programs be consummated at an early date. The LMR programs

in France, West Germany, and Japan offer excellent opportunities for trading U.S. base-program capabilities and results for demonstration-plant know-how. The HTGR program in West Germany offers a similar opportunity. To capitalize on these opportunities, the United States must maintain vigorous and productive base programs for both reactor types -- programs that contribute meaningfully to world knowledge of these systems.

The Panel stresses the importance of the United States maintaining as much influence and leverage as possible in the international community relative to regulation of civilian nuclear power and non-proliferation and safeguards issues. This will require that the nation keep itself in the forefront of advanced-reactor-development in addition to staying on the cutting edge of LWR technology.

DOE's civilian-reactor test facilities, particularly EBR II and FFTF, could be of substantial value in meeting test and demonstration needs for military reactors. Use of these facilities for both civilian and military operations would have the advantages of (1) elimination of a certain amount of duplication, (2) more efficient use of equipment and personnel, and (3) increased exchange of ideas and cross-fertilization of sub-programs. These advantages would primarily accrue to the military, however, since the characteristics of the reactor systems needed by the military are very different from those needed to meet civilian objectives and military operations would undoubtedly be given precedence.

8

There are many disadvantages to combining civilian-reactor and military-reactor activities, including (1) the mixing of diverse objectives, (2) the probability that defense goals would invariably be given a higher priority than civilian goals, (3) the likelihood that infrastructure needs for the two types of activities would be quite different, (4) the difficulty in melding dissimilar management structures, (5) the severe restrictions imposed by classification, and (6) the adverse impact on public opinion. For these reasons, the Panel believes that the military and civilian reactor-development programs should be separately funded and managed. At the very least, the military should pay for its share of development and testing expenses. The recent move by DOE to utilize funds slated for the civilian-reactor program to pay for military-reactor development is, in effect, a direct cut in the civilian-reactor program.

Two of the essential ingredients of any plan to bring nuclear power to its full potential are (1) a balanced and effective program to inform the public about the advantages and the problems of this energy source and (2) a credible nationwide radiation-monitoring system that keeps the citizenry apprised at all times of the extent of its exposure. The Strategic National Plan should address these needs and include any new ideas that DOE may have for satisfying them.

Admittedly, the nuclear industry must take the lead in the public-information area; but DOE should reassess its position regarding

providing information on nuclear energy to the public and complement private-sector initiatives with a carefully selected few of its own. It should, for example, make a concerted effort to clarify for the public the major issues involved in the establishment of permanent waste repositories. The public will not have a positive reaction to such repositories unless it fully understands the risks entailed by building -- or not building -- them and the measures being taken to minimize these risks. DOE should also take the lead in explaining to the public the biological effects of penetrating radiation.

Only the federal government is capable of determining what constitutes a "credible nationwide radiation-monitoring system". It may be that the extensive network of monitoring stations at and around existing nuclear installations is sufficient to supply the required basic data and all that needs to be done to complete the system is to add a few check stations and develop acceptable standards for data analysis, clearing and reporting. The units of measurement employed, for example, should enable the public to readily compare doses received from nuclear power sources with those received from other sources, such as stone houses, ground water and cigarette smoking. DOE, working with the Environmental Protection Agency and NRC, is in an excellent position to propose the basic criteria and guidelines for this system, which would of course be subject to considerable public scrutiny before adoption.

DOE should develop a mechanism for setting up a data base for the overall waste-disposal program that is acceptable to the organizations involved. It should also delineate the methodology for use of this data base. Without a consensus on this important matter, there will be significant disparities in the program and costly duplication of effort.

Reviewing these conclusions and recommendations in the light of this Committee's current initiative, I see several areas where Congressional leadership could be applied beneficially. I suggest that in any Advanced Reactor Development Act that is drafted, the following provisions be included:

1. Reaffirmation of the need to keep the nuclear-power option alive and well.

2. Definition of the role of nuclear power in future national energy plans.

3. Identification of areas where government and the private sector should work together to resolve important nuclear-power issues.

4. Organization of Congressional oversight of Federally-funded nuclear-power endeavors.

5. Establishment of basic funding rules and stable, adequate funding patterns.

6. Encouragement of cost-sharing by the private sector.

7. Direction to the Nuclear Regulatory Commission to supply safety advice and independent safety analyses as required by advanced-reactor-development programs.

8. Authorization of the formation of an Executive Branch task force or a DOE advisory committee specifically charged with responsibility to expedite the development and deployment of advanced nuclear-power systems. (Balancing the "brakemen" with responsible advocates of innovation and improvement.) The duties of this advisory group might include:

    a. Development of the procedures to be followed and the criteria to be used in setting priorities for advanced-reactor R&D programs,

    b. Development of strategic reactor-development plans,

    c. Periodic review of the major reactor-development programs under way,

    d. Periodic review of all collaborative arrangements with other nations to further the development of advanced reactors,

e. Coordination of inter-agency efforts to maximize U.S. influence in the international regulation of nuclear power and special nuclear materials,

f. Improvement of communications and exchange of data on advanced-reactor development among Federal agencies and with the private sector, and

g. Investigation of the feasibility of setting up a credible nationwide radiation-monitoring system.

I hope you will give serious consideration to at least a few of these suggestions. If you would like a clarification of any of them that I have not explained adequately, I would be pleased to give you additional thoughts.

Thank you.

9/22/86

SUMMARY REPORT

FINDINGS AND RECOMMENDATIONS
CIVILIAN NUCLEAR POWER PANEL
DOE ENERGY RESEARCH ADVISORY BOARD

FOREWORD

The full report of the Civilian Nuclear Power Panel of the Department of Energy (DOE) Energy Research Advisory Board (ERAB) consists of this Summary Report and eight appendices, including three sub-panel reports. A brief explanation of the background of the report may help to clarify the Panel's findings and recommendations.

The study that led to the report was initiated by a letter dated August 9, 1985 from Secretary Herrington to the Chairman of ERAB, John H. Schoettler (Appendix A). The key sentences in the letter are:

> .....I am particularly concerned that we may not be doing enough to ensure that the nuclear energy option will be available to meet our future needs.
>
> It is timely that we review our approach to nuclear energy research and development so that it can continue to be a prime contributor to America's energy security, stability, and strength. Achieving this goal will require a concerted joint effort of industry and government that must be carried out with full public support and understanding.
>
> I have asked the Acting Assistant Secretary for Nuclear Energy to prepare a strategic national plan that outlines the

> Department's role in the future development of civilian nuclear power. The plan will identify goals and objectives for a research and development program to meet current and future needs.
>
> This plan will need high level objective review. For this reason, I request that you establish an ad hoc panel of the Energy Research Advisory Board to review and comment on this plan.....

During its first meeting in October 1985, the Panel came to a unanimous conclusion that in order to evaluate the proposed Strategic National Plan for Civilian Nuclear Reactor Development adequately and fairly, it would have to consider the institutional factors involved in addition to the technical factors. The Panel recognized that its primary responsibility was to make a technical assessment, but it also recognized that nuclear power is beset with many crucial institutional problems, the resolution or non-resolution of which could have a material impact on nuclear research and development needs and therefore on the scientific/engineering feasibility of the Plan.

Subsequent discussions by Panel members with the Secretary and his staff and a review of these discussions during the November 1985 scheduled meeting of ERAB resulted in a decision that the Panel should indeed take institutional factors into account. It was agreed that there is considerable precedent for such an enlargement of ERAB's functions, dating back to its very first study (pertaining to the management of DOE weapons laboratories by the University of California) and including the recent infrastructure and international R&D studies. Accordingly, the Panel was divided into three sub-panels:

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I. Light Water Reactor (LWR) Utilization and Improvement

Chairman - H. O. Reinsch
Members - J. H. MacMillan
L. T. Papay
T. Stern
J. M. West

II. Advanced Reactor Development

Chairman - J. J. Taylor
Members - W. B. Behnke
K. F. Hansen
R. F. Walker

III. Institutional Challenges

Chairman - S. Burstein
Members - J. E. Gray
J. M. Hendrie
S. S. Munro
R. Patrick
L. H. Roddis
B. Wolfe

The findings and recommendations presented herein are largely the result of deliberations of these sub-panels, but in every instance they have been reviewed and approved by the full Panel.

With respect to the impact of the accident at Chernobyl in the Soviet Union on the Panel's findings and recommendations, several members of the Panel are involved in comprehensive examinations of that accident and final conclusions on this matter, therefore, will have to await completion of those examinations. The Panel realizes that there are substantial differences between the design of the Chernobyl reactor and the design of the commercial reactors currently in use in the United States and a great divergence in safety policies and procedures between the two countries. Nevertheless, the Panel anticipates that the accident will stimulate debate on a number of nuclear issues during the next few years.

The Chernobyl aftermath reinforces a major finding of the Panel -- outlined in the Institutional Challenges section of this report -- that the techniques of public communication currently employed by the nuclear-power industry and the federal government are not effective and must be improved. The Panel makes several recommendations on this subject.

Appendix B, a presentation by John J. Taylor, Vice President of the Electric Power Research Institute (EPRI) and Chairman of Sub-panel II, is the statement that most accurately reflects the current position of the Panel on the Chernobyl accident.

Finally, the Panel emphasizes that throughout its discussions it was constantly mindful of the fact that industry must take the lead in solving many of the problems that had been or were being identified. The charge to the Panel was to formulate recommendations for action by DOE, however, and consequently the action required of industry is covered only indirectly in this report.

GENERAL FINDINGS AND RECOMMENDATIONS

The Panel unanimously agrees with the Secretary of Energy in his judgment that nuclear fission will play an important role in both near-term and long-range energy supply in the United States and unanimously supports him in his determination to improve the viability of nuclear power sufficiently to bring it to optimal utilization. Because of the continuing growth of the electricity segment of the nation's energy economy and the increasingly vital contribution of nuclear power to that segment, the nuclear option now is one of the relatively few energy technologies that

form the cornerstones of both our national security and our economic health. The loss of nuclear-generated electricity would severely disrupt energy supply in significant areas of the nation.

The Panel doubts that the nation will have adequate long-term security of any type -- military, environmental or economic -- if energy supply is excessively dependent on any one source, particularly foreign oil. There may be periods of a few years' duration when oil, for example, is a glut on the market due to the success of measures such as conservation and the introduction of new sources such as nuclear power, but the inexorable trend in the long run will be significant depletion of domestic oil reserves, substantial increases in prices, and acute aggravation of delivery difficulties. Correspondingly, excessive dependence on coal would incur major economic and environmental penalties, including long-term threats to the stability of the global ecosystem.

Despite the fact that energy does not have a high political priority at present, the Panel believes that DOE must intensify its efforts to keep the overall national energy system strong, flexible and productive. Vigorous action in this regard is particularly important at a time like the present when the public seems to be forgetting the lessons of the past. Nuclear power, as one of the few large-scale options currently available, should have a well-articulated role in federal energy policy. The ERAB report of December 1985 entitled Guidelines for DOE Long-Term Civilian Research and Development included a statement that nuclear-safety and nuclear-waste R&D activities should be "major objectives for the assurance of an adequate supply of economical, safe and environmentally acceptable electric power". The Panel agrees with this recommendation

and points out that since disposal of high-level nuclear waste is solely the responsibility of DOE, the Department's performance in solving the many institutional and technology-application problems involved in the national nuclear-waste program will be as important, if not more important, than any other factor in determining the extent to which nuclear power is utilized in the future.

As an initial step toward definition of nuclear power's role in federal energy policy, the Panel recommends that the Secretary of Energy urge the President to issue a strong policy statement supporting the continued development and deployment of civilian nuclear power, including directives to government agencies to create a more favorable climate for such development and deployment, without reducing protection of the public or the environment.

As another step toward clarification of nuclear power's role in the nation's future energy mix, a high-level Executive Branch task force should be established, with the Secretary of Energy as its chairman, to perform the following functions:

1. Develop long-range objectives for the use of nuclear power in the United States.

2. Provide leadership on international nuclear-policy issues.

3. Oversee the implementation of the policy and/or institutional recommendations contained in this report -- and of other recommendations from other sources as deemed appropriate.

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As stated in the Foreword, the Panel recognizes that the private sector bears the primary responsibility for the viability of nuclear power. The Panel stresses, however, that some of the crucial problems that must be dealt with, particularly in the areas of reactor safety and disposal of high-level waste, to permit nuclear power to realize its full potential are beyond the ability of industry alone to solve. Substantial government initiative and cooperation are required.

Since the dissolution of the Joint Committee on Atomic Energy, Congressional oversight of energy, and nuclear matters in particular, has been diffused. This, in turn, has created a major drain on resources at the highest levels of both DOE and the Nuclear Regulatory Commission (NRC) because officials are required to cope with a multitude of Congressional inquiries and different emphases and directions. A mechanism to focus Congressional oversight is needed.

DOE should cooperate fully with Congress as the latter endeavors to limit NRC's responsibility to questions of public health and safety and to streamline its operations.

The Panel feels that the Strategic National Plan drafted by the DOE nuclear staff does not adequately treat the regulatory and other institutional problems with which the nuclear industry must contend, particularly the problems arising from public concern about nuclear operations. (See letter from J. W. Vaughan, Jr. to J. W. Landis dated December 10, 1985, which is attached as Appendix C.) The Plan is also deficient in that it does not clearly indicate the procedures to be followed and the criteria to be used in setting priorities for advanced-reactor R&D programs.

The Panel advocates revision of the Strategic National Plan to correct these deficiencies and to conform to other recommendations contained herein. These recommendations reflect due consideration of certain programmatic changes made since the Plan was issued, as noted in the appropriate sections.

LWR UTILIZATION AND IMPROVEMENT FINDINGS AND RECOMMENDATIONS

The Panel is convinced that the overriding challenge facing both the private sector and government as they seek to ensure that the nuclear option will be available to help meet the nation's future energy needs is to revive the LWR business. Such a revival would provide a solid foundation for a future buildup of public confidence and a strong commercial rationale for R&D on advanced reactors.

The private sector is doing its part to meet this challenge by spending over a billion dollars a year on operating and administrative improvements, systems upgrading, plant standardization, development of advanced LWR concepts, extension of plant lifetimes, and waste disposal. The government can help by funding worthwhile generic development projects whose commercial applications are too broad, too uncertain, and/or too distant in time to attract venture capital, and also by providing the leadership required to eliminate unnecessary regulatory and other institutional roadblocks.

From a worldwide perspective, the introduction of LWR nuclear power plants to electric power grids over the last 30 years has been a remarkable achievement. But in this country LWR development has come to a sudden

stop. The causes lie with industry, the courts, state agencies, national regulatory bodies, Congress, and the Administration.

The promise of nuclear power was low-cost energy, reliably and safely produced. There are some exceptions, but overall the LWR plants completed in the United States since the TMI accident have been very expensive. As a result, the general public has lost confidence that nuclear power is an economic alternative to other electric-energy sources.

The private sector recognizes this problem and has focused its attention on two areas: capital-cost reduction and improvement of safe and reliable operation. In regard to the former, the private sector has initiated efforts to stabilize plant costs through programs in design simplification and standardization. The centerpiece of this effort is the EPRI Future LWR Program.

Improvement of the safe and reliable operation of nuclear power plants is a multifaceted process. During the past few years the electric utility industry has formed the Institute for Nuclear Power Operations (INPO), the Nuclear Safety Analysis Center (NSAC), and the Nuclear Utility Management and Human Resources Committee (NUMARC). INPO has been charged with responsibility to set germane and effective standards for the operation and maintenance of nuclear power plants and to train operating personnel, NUMARC with responsibility for achievement of a consensus approach to regulatory issues by utility licensees and for improving communications with NRC. Their activities complement current EPRI programs (including those in NSAC, which EPRI administers) to upgrade the operation and extend the useful life of such plants.

The challenge faced by the nuclear power industry in this regard and the ways in which the challenge can be met are outlined in the August 1986 report of the Task Committee of the Utility Nuclear Power Oversight Committee (UNPOC), a summary of which is attached as Appendix D.

The industry must do a better job than it has been doing to date in communicating these activities to the general public if it hopes to increase public confidence in nuclear power to a level commensurate with the relative risk. Strong support from DOE and other government agencies is needed, however, to lend credibility to the industry's public-education program.

The United States (primarily the private sector) has made approximately a trillion-dollar investment (in current dollars) in LWR research, development, testing, support facilities, manufacturing plants, military power units and civilian generating stations. Every effort should be made to extract maximum benefit from this investment, thereby maintaining U.S. technological leadership in the LWR business. As nuclear fission is called upon to contribute an increasing share of the nation's energy supply, the extensive experience and infrastructure developed with and for the LWR should be utilized to the fullest possible extent.

The LWR R&D program will be effective, however, only to the extent that it is coupled with a comprehensive and integrated campaign to eliminate unwarranted institutional (primarily regulatory) impediments to the future development of civilian nuclear power.* These impediments severely hamper the nation's ability to make valid economic comparisons of competing energy options.

*See Appendix H for examples.

In view of the large number of LWR plants with full-power licenses, the first priority should be activities that assure improvement in the safe and reliable operation of these plants. The second priority should be activities related to successful completion and start-up of the LWR plants now under construction. The third priority should be activities that set the stage for future LWR orders to help meet the nation's growing demand for electricity.

One immediate consequence of this line of reasoning is that the joint commitment made by DOE and the nuclear industry to remove and analyze the Three Mile Island-2 core and derive the optimum amount of information from the 1979 accident should be fulfilled as soon as possible. Among the benefits of an expedited completion of this work would be minimization of future destabilizing effects of such accidents on the regulatory process.

ERAB conducted an extensive review of DOE's LWR R&D program in 1984 and 1985 and published its findings and recommendations in May 1985. These recommendations, which are outlined in Appendix E, are still relevant and should be followed.

Specific new recommendations resulting from the deliberations of the current Panel are:

1. Programs Related to Operating Nuclear Power Plants

   - DOE should actively cooperate with EPRI and INPO in their efforts to decrease plant outages, improve overall plant availability, reduce exposure of plant personnel to radiation, and minimize radioactive waste.

- DOE should sponsor generic research in conjunction with industry initiatives to extend the life of operating plants as an alternative to decommissioning.

- DOE should continue to meet its obligations with respect to the cleanup of Three Mile Island-2.

2. Preservation of Options to Complete Cancelled Nuclear Power Plants

- Over $10 billion has been invested in LWR plants that have been cancelled but which the owners might be able to complete at less cost and on a shorter schedule than most other types of new plants. DOE should conduct an independent study of the national impact of decisions on the ultimate disposition of these plants and contribute its insight to all interested parties.

3. Programs Related to Future Nuclear Power Plants

- The performance of the DOE laboratories in the advanced LWR area should be evaluated periodically and changes made as appropriate to improve the effectiveness of laboratory programs. Cooperation between the laboratories and industry in the conduct of these programs should be encouraged.

- DOE should continue to encourage the nuclear industry to optimize contractual arrangements, simplify designs, cut construction times, and generally reduce costs -- <u>without</u>

compromising public or plant safety.

DOE should maintain a basic R&D program on LWR spent-fuel reprocessing with a view to simplifying disposal of high-level waste as well as to assuring a continuing international leadership role for the United States on safeguards and non-proliferation issues.

- The Strategic National Plan should include development of economically attractive advanced LWR concepts that are too generic and/or too far from commercialization for private industry to pick up. Among these concepts should be several with features specifically tailored to facilitate licensing, design and construction.

  Sharing responsibility for these programs with EPRI and other private-sector organizations would expedite the commercialization of the advanced systems that are developed.

The complete report of Sub-panel I, LWR Utilization and Improvement, is attached as Appendix F.

ADVANCED REACTOR DEVELOPMENT
FINDINGS AND RECOMMENDATIONS

Given the importance of adequate supplies of competitively-priced clean energy to the nation's future economic and strategic well-being,

the Panel believes that DOE should be committing at least $200 million annually to its base programs for development of advanced reactors for civilian use. Its advanced-reactor-development plans should be revised to reflect current projections of economic parity with LWR technology and should focus on areas of potential economic breakthrough where commercial application is too distant in time, too uncertain, and/or too broad to attract venture capital.

The Panel recommends that DOE concentrate its development efforts on two advanced-reactor systems: the liquid-metal reactor (LMR) and the high-temperature gas-cooled reactor (HTGR). Both of these systems are capable of producing electricity efficiently. The LMR, when used as a breeder, is generally considered to have the greatest capability among all competing concepts for maximizing economic utilization of the world's uranium resources. The HTGR, on the other hand, has a superior potential to extend the direct use of fission energy to high-temperature industrial applications. The ongoing R&D programs have identified technical advances and innovative design approaches, including incorporation of passive safety features, that enhance the prospects for economic breakthrough with these systems. The four development areas that appear to be most promising, and in which future effort should be concentrated, are:

1. the LMR with metal-alloy fuel and integral pyrometallurgical reprocessing,

2. the LMR with an ultra-long-life core using oxide fuel and appropriate fuel reprocessing,

3. other innovative LMR designs incorporating improvements of systems and components based on operating experience and reflecting the latest construction and manufacturing techniques, and

4. a modular HTGR with prismatic fuel.

To assure the most effective use of resources and a well-focused effort, major tasks in each development area should be sharply defined, with schedules, milestones and success/failure criteria established to permit further winnowing of the alternatives to those with the greatest promise.

If budget limitations force near-term choices among the many tasks in the four recommended development areas, those in the first two areas should be given top priority.

Success in developing these concepts depends strongly on the continued use of:

1. the Experimental Breeder Reactor (EBR) II for the metal-alloy-fuel concept,

2. the Fast Flux Test Facility (FFTF) for the ultra-long-life core concept, metal-alloy-fuel endurance testing, and component/system proof testing,

3. the Steam Generator Test Facility at the Energy Technology Engineering Center for all LMR projects, and

4. a number of facilities at Oak Ridge National Laboratory for the HTGR.

The Panel also recommends that additional collaborative agreements with those nations that have active LMR and HTGR demonstration programs be consummated at an early date. The LMR programs in France, West Germany, and Japan offer excellent opportunities for trading U.S. base-program capabilities and results for demonstration-plant know-how. The HTGR program in West Germany offers a similar opportunity. To capitalize on these opportunities, the United States must maintain vigorous and productive base programs for both reactor types -- programs that contribute meaningfully to world knowledge of these systems.

The Panel stresses the importance of the United States maintaining as much influence and leverage as possible in the international community relative to regulation of civilian nuclear power and non-proliferation and safeguards issues. This will require that the nation keep itself in the forefront of advanced-reactor development in addition to staying on the cutting edge of LWR technology.

DOE's civilian-reactor test facilities, particularly EBR II and FFTF, could be of substantial value in meeting test and demonstration needs for military reactors. Use of these facilities for both civilian and military operations would have the advantages of (1) elimination of a certain amount of duplication, (2) more efficient use of equipment and personnel, and (3) increased exchange of ideas and cross-fertilization of sub-programs. These advantages would primarily accrue to the military, however, since the characteristics of the reactor systems needed by the

military are very different from those needed to meet civilian objectives and military operations would undoubtedly be given precedence.

There are many disadvantages to combining civilian-reactor and military-reactor activities, including (1) the mixing of diverse objectives, (2) the probability that defense goals would invariably be given a higher priority than civilian goals, (3) the likelihood that infrastructure needs for the two types of activities would be quite different, (4) the difficulty in melding dissimilar management structures, (5) the severe restrictions imposed by classification, and (6) the adverse impact on public opinion. For these reasons, the Panel believes that the military and civilian reactor-development programs should be separately funded and managed. At the very least, the military should pay for its share of development and testing expenses. The recent move by DOE to utilize funds slated for the civilian-reactor program to pay for military-reactor development is, in effect, a direct cut in the civilian-reactor program.

The complete report of Sub-panel II, Advanced Reactor Development, is attached as Appendix G.

INSTITUTIONAL CHALLENGES FINDINGS AND RECOMMENDATIONS

A number of the findings and recommendations relative to institutional roadblocks and problems have been summarized in the foregoing sections of this report. To keep the report as brief as possible, they will not be repeated in this section except as necessary to clarify or reinforce a salient point. The findings and recommendations that the Panel believes are outside the purview of the proposed Executive Branch task force will

be presented first. Then those on which the Panel believes the task force should take action will be covered.

1. Activities Outside the Purview of the Executive Branch Task Force

- Assurance of Supply of Professional Personnel

DOE should join industry in formulating a comprehensive plan for university education and research that assures the future availability of talented young engineers and scientists for the nuclear-power field.

- Initiatives in Public-Information and Environmental-Monitoring Areas

Two of the essential ingredients of any plan to bring nuclear power to its full potential are (1) a balanced and effective program to inform the public about the advantages and the problems of this energy source and (2) a credible nationwide radiation-monitoring system that keeps the citizenry apprised at all times of the extent of its exposure. The Strategic National Plan should address these needs and include any new ideas that DOE may have for satisfying them.

Admittedly, the nuclear industry must take the lead in the public-information area; but DOE should reassess its position regarding providing information on nuclear

energy to the public and complement private-sector initiatives with a carefully selected few of its own. It should, for example, make a concerted effort to clarify for the public the major issues involved in the establishment of permanent waste repositories. The public will not have a positive reaction to such repositories unless it fully understands the risks entailed by building -- or not building -- them and the measures being taken to minimize these risks. DOE should also take the lead in explaining to the public the biological effects of penetrating radiation.

Only the federal government is capable of determining what constitutes a "credible nationwide radiation-monitoring system". It may be that the extensive network of monitoring stations at and around existing nuclear installations is sufficient to supply the required basic data and all that needs to be done to complete the system is to add a few check stations and develop acceptable standards for data analysis, clearing and reporting. The units of measurement employed, for example, should enable the public to readily compare doses received from nuclear power sources with those received from other sources, such as stone houses, ground water and cigarette smoking. DOE, working with the Environmental Protection Agency and NRC, is in an excellent position to propose the basic criteria and guidelines for this system, which

would of course be subject to considerable public scrutiny before adoption.

Establishment of Valid Waste-Disposal Data Base

DOE should develop a mechanism for setting up a data base for the overall waste-disposal program that is acceptable to the organizations involved. It should also delineate the methodology for use of this data base. Without a consensus on this important matter, there will be a significant disparities in the program and costly duplication of effort.

- Incorporation of Monitored Retrievable Storage (MRS) in Waste-Disposal Plans

DOE should continue to pursue the required approvals for design and construction of an MRS facility as a forerunner of permanent repositories. The widespread misconceptions about the purpose and capabilities of such a facility should be corrected in a series of public hearings.

2. Actions to Be Taken by the Executive Branch Task Force

- Definition of Action Program

The task force should prepare a clear and concise outline of the actions required to resolve the

institutional problems of civilian nuclear power. It should then assign priorities to these actions and develop a scope, cost estimate and schedule for each project.

- Expediting of Nuclear Licensing Reform

The task force should vigorously advocate early passage of a nuclear-licensing-reform bill that streamlines both legislative and administrative licensing procedures.

- Extension of Nuclear Liability Protection

The question of how best to continue liability insurance for the nuclear-power industry is receiving unprecedented attention in Congress. The task force should carefully examine the various proposals being given serious consideration and support those that contribute to effective and sensible solutions to the problems of evaluating the liability exposure of the industry and determining the premiums to be assessed.

- Liaison with Utility Nuclear Power Oversight Committee (UNPOC)

The task force should maintain a close and cordial relationship with UNPOC, exchanging information and opinions as appropriate.

- Analysis of Financial Risks and Benefits of Large Central Generating Stations

  Studies should be initiated by the task force that will lead to recommendations for changes in state and federal laws and Federal Energy Regulatory Commission (FERC) administrati procedures to balance the financial risks of large central-station projects, both coal and nuclear, more equitably with the financial benefits.

- Support of NRC and Nuclear Industry in Achievement of Safety Objectives

  One of the prerequisites of viability for nuclear power is achievement of the safety objectives that have been developed by NRC and the nuclear industry. The task force can provide valuable assistance in this regard by facilitating the transfer of pertinent data and analyses, ensuring that the need for and impact of new regulations are reviewed before they are put into effect, advising the NRC on elimination of excessively conservative and non-substantive existing regulations, and fostering the creation of a comprehensive private-sector panel to interface with NRC on matters of general concern and help establish performance standards for NRC. The task force should also encourage NRC to increase its reliance on performance reviews as opposed to document and procedure reviews.

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- Competitive Loans by Export-Import Bank

The task force should weigh the advantages and disadvantages of various types of financing for foreign nuclear projects in which U.S. vendors may have substantial roles and suggest ground rules for participation by the Export-Import Bank.

- Coordination with State Agencies

Existing methods for regulating electric utilities are inconsistent with efficient long-term investment strategies and the timely adoption of new technologies. Because nuclear power is a rapidly evolving technology requiring large long-term investments, the current regulatory climate constitutes a serious impediment to its use. If nuclear power is to play a significant role in the nation's future energy supply, therefore, state regulation of electric utilities must be reformed.

In the short term, it is essential that the nation solve the serious financial problems that have arisen in a number of electric utilities from the reluctance of state regulators to permit full recovery of the costs of licensed nuclear facilities. The solutions to these problems must be compatible, however, with the creation of a regulatory climate that permits regulators and electric utilities alike to develop

efficient long-term investment strategies and adopt new technologies on a timely basis.

In this context, the task force should work with the National Association of Regulatory Utility Commissioners, the National Governors Association, and the National Conference of State Legislators to:

- Foster agreement among all involved parties on forecasts of future power requirements.

- Expand efforts to create more favorable utility-commission attitudes toward nuclear power and thereby remove some of the financial uncertainties from utility operations.

- Develop new ways to ease rate shock and improve utility cash flow.

- Encourage development and implementation of effective certification systems for proposed power projects.

- Establish reference criteria for recovery of construction costs during the construction period.

- Promote multi-state agreements on the certification of need for specific installations that serve

two or more states.

The complete report of Sub-panel III, Institutional Challenges, is attached as Appendix H.

Senator FORD. Thank you, Mr. Landis.

Mr. O'Connor, I understand you have to catch an airplane. How much time do you have?

Mr. O'CONNOR. As much as you would like, Senator.

Senator FORD. Well, I do not have very much either, and I do not have to catch a plane. So we will go from there.

Let me ask you this, and anybody who wants to may respond, when I ask a question, why, just jump right in and let us chat some about it. How important is it, Mr. O'Connor, that the technology have been demonstrated before you would commit to it?

Mr. O'CONNOR. It is important, Senator, that we have that basis. The whole history of our industry is one of incrementalism, and you do not go to the next step until you have proven out the first one.

We did that with our first unit at Dresden station almost 30 years ago. It was a small unit, 180 megawatts, one-fourth the size, one-fifth the size of the next generation of technology.

And I think because of the regulatory environment on the other side, which is the economic regulator, they are not going to give you a chance to fail. If you fail, it is totally on you.

So by nature we are a somewhat cautious industry when it comes to adaptation to various technologies. And we are going to have to have that foundation and do it in a logical, progressive manner. And that is why we advance the notion that the next increment will be the advanced light water reactor, rather than some of the other technologies that we have talked about.

Senator FORD. How important is it that the federal government get involved financially in order to make it move ahead?

Mr. O'CONNOR. It is very important that we have a partnership. I guess the importance that we would assign is really one of priorities. Our first priority would be the advanced light water reactor.

At the same time, we do not think we can ignore the liquid metal or HTGR. I say that as a past chairman of the Clinch River Breeder Reactor Corporation, which was the private industry and public industry consortium that worked very hard for almost a decade on Clinch River. We failed in that area.

We think it is very important that we maintain the knowledge of that technology and that we work with other countries to advance it. But we just do not think it is going to serve as the next component that will be ordered.

Senator FORD. Let me ask you this. If you needed, as you stated, the demonstration, and you prefer the advanced water reactor, when would you need that to be demonstrated? What kind of time frame are we talking about, Mr. O'Connor?

Mr. O'CONNOR. We are probably talking about the middle to late nineties, is our best guess right now as to when it might be feasible to go to the next step up in technology.

Senator FORD. You said you had turned the facility on when, last Friday?

Mr. O'CONNOR. Yes, when we received our full power operating license from the Nuclear Regulatory Commission for a light water reactor, the twelfth in our system.

Senator FORD. Now, Mr. Taylor, let me ask you this. Utilities—we all get complaints every once in a while, but if you could advise

us on how to structure an advanced reactor program that is not going to get any more money—you know, let us lay it out there.

We are in a time of hurt, I have heard it explained around here. What would you advise us to do?

Mr. TAYLOR. I would strongly suggest that you reinforce the goals for each of these programs on a truly nationally stable basis. That is, one of the difficulties that the entire research and development community has had, both in the private and moreso in the government sector, is a shifting of goals, a shifting of emphasis.

I think what is needed most, particularly if no infusion of moneys are available—and I am realistic enough to recognize that that is where we stand in the country today—that establishing these goals as these are the things these three programs are going to meet, here is how we are going to get there, here is how we are going to be measured, is the most important thing that your support and guidance could provide.

Senator FORD. I find, though, that those who are willing to pay a little money to get some folks around town to push pretty hard and get some interest in a certain area or new procedure or something, we find that over a very short period of time they begin to surface and the bubble comes to the top.

The first thing you know we are putting a little money, $10 or $15 million into it, which is peanuts. But then all of a sudden we are nickel and diming everything else to death.

Should we go ahead and build a white elephant and see if it works? Or should we just kind of nickel and dime all of these little projects?

It is awful hard to set a goal out there and get to it when you find other entities or outside interests become involved in a new procedure. I am trying to select my words very carefully.

Mr. TAYLOR. This is probably the most single serious difficulty in our development programs at this time, and here is our response. In the case of the advanced light water reactor, we have established, working with our utilities, a goal, a ground rule, that there will not be a need for a major demonstration project in order to permit selection of that system.

This includes the increased passive safety features, which would have to be tested very thoroughly, but which would not require a whole new subsidized plant in order for a utility to make a choice to go ahead.

And as Mr. O'Connor has said, if we can incorporate, build these improvements on the base of the proven technology, then the utilities have basically 30 years of experience on which they can make their choice and move ahead with reasonable—with very low technical risk.

Now, in the case of the two advanced systems we are not at that stage. And on the other hand, we do not see, as has been discussed earlier in this proceeding, a great urgency to build a power plant.

Rather, we have the time to increase the level of innovation, to increase the level of performance and safety and costs, and the development program should be focused on that, without yet a specific schedule to build what will ultimately be needed, which is a large, very expensive demonstration project to prove that all the

things that have been developed will be put together to produce a reliable and predictably economic power producer for the utilities.

Senator FORD. Mr. O'Connor, we are always hearing here that Federal support for nuclear energy is an unfair subsidy to the utilities and to the industry as a whole. Now is your chance to tell us why that is not so.

Mr. O'CONNOR. I think it is important, at a time when we are trying to develop technologies for use way down in the future, if security of national energy supply is an important item on the national agenda, we think it is important that we have a partnership with government to develop these technologies.

The fact of the matter is that today the electric utility industry is not the most financially healthy industry, and the discretionary dollars that are there are very, very few. We do believe through our programs associated with the Electric Power Research Institute that we are doing a great deal toward helping to fund these programs.

But we also recognize that to move it forward in any substantive way that it will take the cooperative work with the government, we believe, to get there.

Senator FORD. Mr. Landis, tell us how your panel reacted—it was part of your statement. I think you gave six or eight reasons and you recommended that they keep the civilian and military research and development separate, or at least that each would pay its own way.

Tell us how your panel reacted to the significant involvement of the civilian nuclear R&D program budget in essentially defense tasks?

Mr. LANDIS. We considered that at great length and debated the pros and cons, as I have indicated in my testimony. And we came to the clear conclusion that the cons were heavily predominant, that there are many more reasons not to mix civilian and military research development than there are reasons to go ahead with such a mixture.

Senator FORD. What kind of reaction did you get from the Department when you made that recommendation?

Mr. LANDIS. As far as I was told, they agreed with us.

Senator FORD. Have they implemented your recommendations?

Mr. LANDIS. I do not think they have, but——

Senator FORD. I can tell you, they have not. So I will be more factual about it. You may not deal with them every day. They have to deal with me. We will leave it on that basis.

One final question. All of you have referenced Japan and France as moving ahead. What is the difference in the attitude of the people of those two countries compared to here?

What has caused the pressure to go on and to get it done, and not have the kind of problems we apparently are having here? As you stated, we got them ready to go and cannot get them cranked up.

Mr. O'Connor.

Mr. O'CONNOR. I can possibly try. I think the difference is a national commitment, and again the view from government that the nuclear power option is a very important one to preserve and enhance. And that is shared with industry.

I had dinner a few weeks ago with Mr. Hira Iwa, who is chairman of Tokyo Electric, the largest nuclear supplier in Japan today, and they are continuing to add increments of capacity. And he and his colleagues have a very hard time understanding the constant tug of war that seems to exist between governmental entities, both on a national as well as local level, and the companies themselves.

He said that situation does not exist in Japan. There is a spirit of a mutual consensus on what needs to be done, and that has provided for an accommodation that has permitted these plants to be built in a relatively short time period.

They do in effect have standardization. They do in effect have one-stop licensing. They do in effect have pre-approval of sites, none of which we have in the United States.

And until we get to that point, it is very unlikely in this nation that we would find a utility again willing to undertake the construction of a nuclear plant.

Senator FORD. Mr. Taylor.

Mr. LANDIS. I might comment on perhaps some underlying reasons for the national commitment that Mr. O'Connor described so well. Japan has a tremendous need to establish independence. Even today, they are at the mercy of tremendous logistical supply of fossil fuels. We do not feel that same need.

The second was alluded to in Mr. Schlesinger's discussions. They have an innate conviction of the importance of export, and I believe, although they have a national position that they are not in any major sense pursuing the export market in nuclear power, that this is a long range goal.

And their version of export is not to export materials, but to export value added through equipment, through the services and software in this nuclear power program. Vast amounts of money in the future will be devoted to expanding nuclear power, and Japan I believe is preparing to be a very important factor in that in the international marketplace.

Senator FORD. Well, tell me about France now. Everybody is talking about Japan. Let us get to France a little bit. I heard a lot about it here when we were talking about Nevada.

Mr. TAYLOR. The French national commitment, if anything, is more strong and determined than the Japanese. And the first comment I made——

Senator FORD. Is that a government commitment, irregardless?

Mr. TAYLOR. Not irregardless. They too are coping with questions associated with public concerns, particularly since Chernobyl, and very vigorously responding to those. But a true national commitment, based again on a conviction that comes from the very things that Dr. Schlesinger said to us this morning.

They do not want to be dependent upon imported fossil fuels. They do not have oil of any kind themselves and they have got to be prepared in the future for that. Export is not being pushed out into the future, as in Japan, but France is actively exporting nuclear equipment around the world, has moved recently into the People's Republic, as you well know, when the U.S. companies were prevented from lack of a nuclear agreement to do so.

And you mention any place where there is a potential market for nuclear power and often the President himself, Mitterrand, is there helping to sell nuclear power equipment for France.

Senator FORD. Mr. Landis.

Mr. LANDIS. I would like to add maybe a little note of pessimism here about our ability. We do not have a national commitment, but there is another area where we are failing. We are not applying as much intelligence and orderliness to our reactor development programs as either the Japanese or the French.

They develop specific and comprehensive criteria that they want to meet. They then develop the procedures that they are going to follow to meet those criteria. We have not done that.

And the energy research advisory board has been trying to get the Department of Energy to set up specific criteria, specific procedures, for the advanced development program, advanced reactor development program. And we have not seen any results as yet.

And that is one area where I think we have to keep pressing, because if we do not develop these criteria and the procedures we are going to keep falling farther and farther behind. That is why I recommended a provision in the proposed Act that calls for the establishment of a group that would have that particular responsibility.

Senator FORD. Thank you, Mr. Landis.

I am going to ask a selfish question. Mr. O'Connor, I have kept you here. Is the Congress on the right path with Senator Domenici's bill and mine, which has now passed the Senate, as it relates to uranium enrichment procedures?

Mr. O'CONNOR. Yes, sir, it certainly is in our judgment. In fact, this Committee and this Subcommittee is really the one thing that we can point to and hope for in the actions you have taken and have talked about taking, as the best opportunity to put things back in motion and move forward and make the kinds of things that we have talked about this morning possible.

Senator FORD. On that positive note, we will have other questions for all of the witnesses, including DOE, today. They will be submitted to you in writing and I hope you will respond as soon as you possibly can.

There will be other Senators who are attending other hearings this morning, who were unable to be here, who will have some questions. So we will leave this open for a couple of weeks.

You all have been mighty nice this morning, very patient, and we do appreciate your attendance and your expert advice.

This hearing is adjourned.

[Whereupon, at 12:47 p.m., the hearing was adjourned.]

APPENDIX

RESPONSES TO ADDITIONAL QUESTIONS

Department of Energy
Washington, DC 20585

June 13, 1988

Honorable Wendell H. Ford
Chairman
Subcommittee on Energy Research
and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

On May 24, 1988, Theodore J. Garrish, Assistant Secretary for Nuclear Energy appeared before your subcommittee to discuss the Department's nuclear reactor research and development program.

Following that hearing, you submitted written questions, on behalf of Chairman Johnston, Senator Sasser, Senator Hecht, and Senator McClure for our response to supplement the record. Enclosed are the answers to those questions, which have also been sent to Chairman Johnston, Senator Sasser, Senator Hecht and Senator McClure.

If you have any questions, please have your staff call Michael Gilmore on 586-4277. He will be happy to assist.

Sincerely,

for Rebecca C. Thompson

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosures

J. BENNETT JOHNSTON, LOUISIANA, CHAIRMAN
DALE BUMPERS, ARKANSAS
WENDELL H. FORD, KENTUCKY
HOWARD M. METZENBAUM, OHIO
JOHN MELCHER, MONTANA
BILL BRADLEY, NEW JERSEY
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WYCHE FOWLER, JR., GEORGIA
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United States Senate
COMMITTEE ON
ENERGY AND NATURAL RESOURCES
Washington, DC 20510-6150

May 25, 1988

Mr. Theodore Garrish
Assistant Secretary
Nuclear Energy Programs
U. S. Department of Energy
Washington, D.C. 20585

Dear Mr. Garrish:

I want to thank you and Dr. Bunch for presenting testimony before the Subcommittee on Energy Research and Development on the Department's nuclear reactor R&D program.

As a follow-up to the hearing, I am enclosing questions from a few of my colleagues, to be provided for the printed hearing record. I am requesting that the answers to these questions be provided to the Committee no later than June 10, 1988.

If you have any questions concerning this request please contact Mary Louise Wagner at 202-224-7569.

Sincerely,

Wendell H. Ford
Chairman, Subcommittee on Energy
Research and Development

WHF/tc

QUESTIONS FOR TED GARRISH (DOE)
FROM SENATOR McCLURE

1. Within DOE, Defense Programs is considering the MHTGR as a candidate for the New Production Reactor (NPR) which will be required in the late 1990's. Similarly, DOE's Nuclear Energy progress has embarked on a design and licensing effort for a commercial HTGR. Would it not be appropriate for DP and NE to coordinate their efforts? Wouldn't this maximize our payback on reactor development by providing the U.S. with a modern, reliable system for defense materials production as well as the option for an advanced plant for commercial electrical generation?

2. While assuring our domestic energy supplies is the paramount objective, the U.S. balance of trade will require that we have new exportable technologies and goods. Shouldn't our advanced reactor development policy give strong consideration to the exportability and total world market available to the nuclear technology to be demonstrated?

3. Nuclear power has made an increasingly important contribution to electrical generating needs in the U.S. and several other countries. While continuing to expand nuclear electrical production will reduce oil and natural gas consumption and help reduce CO_2 (green house) and acid rain concerns; a higher temperature nuclear energy source will be required if nuclear is to contribute to the much larger industrial process heat market. In the longer term, such a high temperature heat source could also be used for coal gasification and other synthetic and portable fuel production. Should our advanced reactor development policy give strong consideration to advanced reactors which can provide process heat, as well as electricity?

4. In recent years, Congress has demonstrated consistently strong support for the Modular HTGR. Why is DOE so resistant to accelerating the MHTGR design and initial project in response to this support?

5. As you probably already know, I am extremely supportive of DOE's research in space and defense power systems. This is an area where nuclear power will clearly be filling a need that no other technology can match. I am, however, deeply concerned that the ramping up of this program will have a detrimental effect on the civilian reactor research program. We already see this happening in the '89 budget request: the space/defense power systems budget request is up by $32 million, and the civilian programs have been reduced by almost exactly that same amount. This is not acceptable to me. Any increase in space/defense systems must be incremental to the civilian program. Furthermore, since the space/defense programs have ultimate "users" (NASA and/or DOD), I would think that user fees should fill in this gap, rather than taking it from the hide of the already lean civilian program. Do you care to comment?

6. How much money is DOE planning to spend on the large, advanced LWR work? How much on the 600 MW_e plant? How does the Department counter criticisms that the LWR industry is sufficiently mature that it ought not to receive <u>any</u> federal assistance? Since the 600 MW_e plant size is more likely to fit into the capacity planning schemes of most U.S. utilities, why is work on the larger plants being pursued at all? Who is likely to order the larger-sized plant?

7. In your testimony, you state what is obvious, that is, that introduction of advanced reactor technologies into the market place depends on the attractiveness of the technology to utilities and to the public. What forum do you use to get utilities and the public to weigh in on these matters?

8. How much international interest is there in the extended-life oxide core work being done at FFTF? How much money is being contributed by foreign parties?

9. How much international interest is being shown on Argonne's Integral Fast Reactor (IFR) program? When will the IFR fuel cycle demonstration be completed?

10. Comparatively speaking, how mature are the advanced LWR designs compared to the modular HTGR design? How much additional time would be required to bring these designs to the point where a prototype plant could be constructed?

11. How much revenue does DOE expect to receive annually from the sale of steam at FFTF following completion of the "Power-Pac" addition? How does this compare with the annual operating costs of FFTF?

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Followup Questions for DOE -- Ted Garrish
From Senator Johnston

1. By my calculations, over 40% of the total nuclear energy R&D budget goes toward systems with primarily space and defense applications.

-- Shouldn't we be focusing more resources on advanced civilian reactor development?

2. Is this competition for federal R&D funding between civilian and defense needs, won't the defense side inevitably win?

3. Should we restructure the Department's reactor R&D program to include a demonstration project?

-- How much would a demonstration cost?

-- How long should a demonstration program last?

4. Clearly, we could not fund 3 programs through the demonstration phase. Should we set up a program that selects one of these technologies through a phased competition?

-- Does it make sense to have the LWR, LMR, and HTGR in such a competition, or are the time frames so different to make this unworkable?

-- Would it make sense to have the LMR and HTGR in such a competition?

-- What would be a realistic time schedule for such a competition?

5. If the Department were to structure a program to include a demonstration of one of the 3 reactor systems, how would it be structured?

-- How much R&D -- how many years and how many dollars -- would be required on each program before selecting a single system for demonstration?

-- What would be the criteria for selecting which system to demonstrate?

6. Both the liquid metal reactor and HTGR represent new technologies. Can we realistically expect that either type of reactor would be built by a utility without a demonstration first?

-- Shouldn't the liquid metal program and HTGR program be funded at an equivalent level at this point? Aren't both reactor types in the category of long-term, high-risk R&D, which the Administration has committed to support?

7. Should we be spending as much as $6 million on so-called large plant studies, or certification of 1,300 megawatt size reactors? Isn't it clear that utilities are more likely to build smaller reactors next?

-- What does NRC certification mean? How would this ease the licensing process for a utility building such a reactor?

8. The funding requested by the Department for the HTGR program in fiscal year 1989 would go primarily toward an NRC licensing review. What does that entail? Will this ease the licensing burden for a utility building an HTGR?

9. A significant amount of funding is still directed to programs and facilities that were part of the post-1983 breeder program.

-- Have these facilities been successfully integrated for use in the liquid metal program?

-- What level of funding goes to international breeder programs?

-- Why should we still be spending any money on breeder R&D?

10. What are the long-term plans for the liquid metal program? When will the Department pick between the two conceptual designs now being developed by General Electric and Rockwell?

-- At what level of funding will this program continue after a single design is selected?

-- What will that get us?

11. I recall that several years ago DOE was planning to conduct a facilities optimization study to evaluate the current use of our facilities and get at the issue of how we can better use those resources.

-- What was the outcome of that study?

-- What action was taken as a result?

12. What is the current mission of the Fast Flux Test Facility?

-- What will that get us?

13. What is the current mission of EBR-II?

-- What will that get us?

-- Do we need both FFTF and EBR-II?

14. What does the term "passive safety system" mean? Is there really such a thing as an "inherently safe reactor"?

STATEMENT AND QUESTIONS OF SENATOR JIM SASSER
Committee on Energy and Natural Resources
May 24, 1988

I have some comments regarding the Oak Ridge research reactors. As a general point, I would like to inform DOE that I would like to see HFIR, the Tower Shielding Reactor, and the other reactors at Oak Ridge up and running as soon as the appropriate procedural and other necessary changes have been completed. I also want the Advanced Neutron Source program to proceed at a vigorous pace. I am disturbed that there is evidently some talk within DOE about relocating some of these reactor programs, such as our joint program with Japan on shielding, to other DOE facilities. I strongly oppose such a move. The Oak Ridge reactors provide the United States with many important and unique capabilities.

I am particularly concerned about the way DOE is handling its decision-making on the Tower Shielding Reactor. Recently, our office heard that DOE had decided to shut down that reactor permanently and that the Japanese shielding program would not proceed. Now we hear that DOE is suggesting that this work be moved. I am very concerned about the way in which this matter has been handled. First we were told the program was going to be terminated. Then we find that it is simply a move to shift the work elsewhere. As I have previously stated, the tower facility is unique and is currently the central experimental facility for the joint shielding program which is co-funded by the Japanese. Their breeder program and, potentially, all of our reactor programs, stand to benefit from improved shielding.

I would appreciate a written response from the Assistant Secretary for Nuclear Energy or other appropriate DOE program managers regarding the status of the reactor program at Oak Ridge, with particular emphasis on the issues I have raised.

QUESTIONS FROM SENATOR HECHT for DOE

1. What research is the Department doing on light water reactor technology or fuel fabrication technology that will allow existing or new light water reactors of conventional design to transmute transuranic waste? How much money has the Department budgeted for this work in FY 1989? What additional work of what importance could be done if the FY 1989 appropriation were 10% higher than in the President's budget?

2. What research is the Department proposing to do in FY 1989 with regard to the Sodium Advanced Fast Reactor (SAFR), a waste burner for light water reactor waste? How much money has the Department budgeted for this work in FY 1989, and what additional work could occur if the FY 1989 appropriation were 10% above the President's request for this work?

3. What other work is the Department doing on technology to burn light water reactor waste, and how much money is budgeted for this work in FY 1989?

4. Please indicate whether there is any research of which you are aware on how fission product waste may be destroyed through waste burner technology?

5. How is the Department keeping abreast of research being done abroad on waste burner technology? What countries have done the most research in this area? What countries have done the best research in this area?

6. If waste-burner technology can be perfected to eliminate transuranic waste, wouldn't this eliminate the need for a repository? Couldn't any short-lived fission product waste that couldn't also be transmuted, be simply stored above ground in a MRS-type facility for the fifty years or so required for them to decay to relatively safe levels?

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR ENERGY R&D

Question 1: By my calculations, over 40% of the total nuclear energy R&D budget goes toward systems with primarily space and defense applications. Shouldn't we be focusing more resources on advanced civilian reactor development?

Answer: The Department believes that the Fiscal Year 1989 budget request strikes a reasonable balance, within existing resource constraints, among several high priority programs including civilian reactor development and space and defense power systems. We believe that the objectives of each program can be met on a reasonable schedule.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR ENERGY R&D

Question 2: Is this competition for federal R&D funding between civilian and defense needs, won't the defense side inevitably win?

Answer: The Department views both civilian reactor development and space and defense energy system development as high priority programs that receive resources appropriate to the objectives and pace of each. We would be pleased to work with the Congress, through the appropriation process, to determine the best path to achieve our mutual objectives for these programs.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 3: Should we restructure the Department's reactor R&D program to include a demonstration project?

-- How much would a demonstration cost?

-- How long should a demonstration program last?

Answer: The Department's civilian nuclear reactor R&D program does not need to be restructured to commit to a demonstration project at this time.

The advanced Light Water Reactor (LWR) can be fully engineered without a full scale R&D demonstration; limited R&D is sufficient to support certification of advanced LWR designs. Ultimately, the advanced Liquid Metal Reactor (LMR) and modular High Temperature Gas Reactor (HTGR) will probably require operation of a full scale prototype before either the NRC or industry will be prepared to consider such concepts as standardized plants. The exact scope and timing of any such demonstration would depend on a number of factors including the degree of private sector support. Our programs are structured to bring each technology to the point where it can be evaluated by the marketplace for further demonstration and commercial deployment.

A demonstration project, which would require private sector cost sharing, for either an advanced LMR or modular HTGR

Answer 3
(continued): would cost roughly a billion dollars. The time required to complete such a project would be about 7 years from the beginning of preliminary design through reactor startup.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 4: Clearly, we could not fund 3 programs through the demonstration phase. Should we set up a program that selects one of these technologies through a phased competition?

-- Does it make sense to have the LWR, LMR, and HTGR in such a competition, or are the time frames so different to make this unworkable?

-- Would it make sense to have the LMR and HTGR in such a competition?

-- What would be a realistic time schedule for such a competition?

Answer: A competition among these three technologies does not make sense. Each has the potential to meet the requirements and expectations of the public, the investors and the industry, and each should have the opportunity to prove its worth. To do this, each should be fully designed and reviewed and certified by the NRC before proceeding to the next phase.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 5: If the Department were to structure a program to include a demonstration of one of the 3 reactor systems, how would it be structured?

-- How much R&D -- how many years and how many dollars -- would be required on each program before selecting a single system for demonstration?

-- What would be the criteria for selecting which system to demonstrate?

Answer: A program structured to provide incentives to develop commercial versions of passively safe reactors should include the Light Water Reactor (LWR) as a candidate. Please see our answer to your previous question on the need for competition among these technologies.

The Department of Energy believes that, ultimately, the LMR and the HTGR could play a role in meeting U.S. energy needs. However, a program could be structured to support construction of first-of-a-kind reactors for one or all technologies. We believe that certain R&D would need to be completed to answer questions concerning safety margins, economics, and fuel cycle technology before the private sector would exhibit sufficient interest to warrant proceeding with a costly construction phase.

Answer 5
(continued): For example, selection of an advanced LMR should not be made without the benefit of a completed IFR metal fuel demonstration; a program requiring approximately another 5 years and $120M to complete. Selection of the HTGR should not be made without completion of the magnetic circulator bearing development, fuel performance testing, control assembly development and related R&D.

The criteria used to make a choice would include an assessment of how licensable is the design, the degree of simplicity and passive safety embodied in a particular design, plant economics including capital and operating costs, fuel cycle closure and economics, technological maturity and operating experience, industrial/utility interests, international interests, and public acceptability.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 6: Both the liquid metal reactor and HTGR represent new technologies. Can we realistically expect that either type of reactor would be built by a utility without a demonstration first?

-- Shouldn't the liquid metal program and HTGR program be funded at an equivalent level at this point? Aren't both reactor types in the category of long-term, high risk R&D, which the Administration has committed to support?

Answer: Both the advanced LMR and the modular HTGR technologies are well understood: LMR and HTGR facilities have been built and operated in the United States thereby establishing a proven technology base for these concepts. The design development program for the LMR and the HTGR program are funded at equivalent levels. The purpose of these programs is to verify cost, reliability, economics and licensability in order to confirm that new generation plants meet the expectations of the public, the investors and the industry.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 7: Should we be spending as much as $6 million on so-called large plant studies, or certification of 1,300 megawatt size reactors? Isn't it clear that utilities are more likely to build smaller reactors next?

-- What does NRC certification mean? How would this ease the licensing process for a utility building such a reactor?

Answer: Certification is a process under which safety questions concerning a reactor design are resolved in a generic review rather than during individual plant licensing proceedings. Safety questions addressed in the certification review then cannot be reopened in the individual licensing proceedings. An NRC certification is provided for a 10-year period and is renewable. Once certified, the plants can then be deployed as standardized plants.

The certification process of the 1300 MWe advanced LWR's is taking place in parallel with NRC's development of certification and standardization policy and procedures. The advanced LWR certification is thereby the vehicle for implementation of this policy and for the demonstration of regulatory predictability which is necessary for all types of advanced reactors.

Answer 7
(continued): In addition to serving as a vehicle for implementation of NRC's standardization policy, the plants will be available as options for standard plants in the 1990's.

The 1300 MWe advanced LWR's being certified represent the best LWR technology available worldwide; success in certification will make them available in the United States. Many utilities are of a size such that they might prefer these plants; other smaller utilities might prefer to await completion of development of smaller plants.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 8: The funding requested by the Department for the HTGR program in fiscal year 1989 would go primarily toward an NRC licensing review. What does that entail? Will this ease the licensing burden for a utility building an HTGR?

Answer: The FY 1989 Department of Energy High Temperature Gas Reactor (HTGR) funding request ($7.7 million) will support a modest level of modular HTGR preliminary design work. Based on this design work, interface meetings, briefings, and reviews will be held with the Nuclear Regulatory Commission (NRC). The Preliminary Standard Safety Analysis Report (PSSAR) Outline is scheduled to be completed and submitted to the NRC during FY 1989. The PSSAR Outline will be the basis for the PSSAR and other required licensing documents. These interactions with the NRC as well as those conducted over the past 3 years (which include review of the HTGR Preliminary Safety Information Document and issuance of an NRC Safety Evaluation Report and Licensability Statement) will provide the basis for assessing the regulatory and safety issues associated with the concept.

3UESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 9: A significant amount of funding is still directed to programs and facilities that were part of the post-1983 breeder program.

-- Have these facilities been successfully integrated for use in the liquid metal program?

-- What level of funding goes to international breeder programs?

-- Why should we still be spending any money on breeder R&D?

Answer: All operating liquid metal program facilities have been successfully integrated into the overall advanced reactor design research and development (R&D) program. The principal Nuclear Energy test facilities are at the Argonne National Laboratory-West. Westinghouse Hanford Company, and Energy Technology Engineering Center sites. A concerted effort has been conducted to consolidate activities including shutdown of facility operations no longer required and the expanded utilization of remaining facilities in support of Department of Energy (DOE) programs. This effort has resulted in cost-effective operation and use of the principal test facilities in conducting test program and development activities for the LMR program as well as other DOE programs.

Answer 9
(continued): DOE has undertaken a number of activities in cooperation with foreign partners. These activities include reactor core evaluation and development, shutdown cooling system development, oxide fuel irradiation tests, materials tests, operational reliability testing, component development and testing activities, and related advanced reactor design studies and evaluations. The estimated costs of these tasks are $25 million in FY 1989; costs will be shared approximately 50-50 with foreign partners.

Because most of this technology under development in the DOE programs is applicable to both foreign breeders and advanced domestic LMR's, both the United States and foreign partners benefit from the results of these cooperative technology development programs. Breeder reactors are essential to the long-term viability of the nuclear option, not only because they conserve uranium resources, but because they promise closure of the nuclear fuel cycle in an economical and environmentally attractive manner. Both advanced LMR's and breeders also offer highly desirable safety features and lower electricity costs. Improvements in safety and economics are prime objectives of the current technology R&D development in the United States as well as foreign countries.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 10: What are the long-term plans for the liquid metal program? When will the Department pick between the two conceptual designs now being developed by General Electric and Rockwell?

-- At what level of funding will this program continue after a single design is selected?

-- What will that get us?

Answer: Selection of a reference advanced LMR concept will be made this fiscal year. Long-term plans are to continue design innovation for the reference concept as part of the advanced conceptual design activities that will begin in FY 1989. With appropriate private sector interest and congressional support, detailed design activities could be initiated in the early 1990's. These design efforts will include continued interactions with the Nuclear Regulatory Commission necessary for the follow-on detailed concept demonstration and certification process. The level of DOE funding required to achieve continued design innovation and development is expected to be approximately $15 million per year.

The completion of advanced LMR design activities and eventual demonstration will lead to an advanced reactor design that has high safety margins, passive means of reactor shutdown and heat removal, and economic competitiveness with other contemporary forms of electricity production. For the long

Answer 10
(continued): term. the concept will provide the U.S. with the technology base to construct breeder reactors should this be necessary.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 11: I recall that several years ago DOE was planning to conduct a facilities optimization study to evaluate the current use of our facilities and get at the issue of how we can better use those resources. What was the outcome of that study? What action was taken as a result?

Answer: Conclusions from the facilities optimization study were:

- Major facilities--such as the Fast Flux Test Facility, the Experimental Breeder Reactor No. II, and the Energy Technology Engineering Center--have evolved such that while there is some overlap in capability, there is currently little overlap in functional utilization.

- To achieve further significant facility cost reductions would require consolidation and loss of unique facility test capabilities currently required in the civilian reactor and space and defense power systems development programs.

- Based on known program needs, reactor irradiation requirements could be conducted at one site at some future time; however, there are inherent risks and penalties that must be considered in consolidating

Answer 11 (continued): program activities within a single reactor facility, such as an extended outage of the single facility.

- o Implementation of any potential facility closeout decision requires advance planning and 2 to 4 years for shutting down a major facility to minimize program disruptions and overall Government costs.

- o Cost reduction assessments and initiatives are underway at all of the sites. Efforts should be continued to develop and to achieve, as appropriate, further improvements that are cost beneficial.

The actions taken as a result of the study include:

- o A metal fuel/oxide task force was established. Their recommendations resulted in a decision to convert the FFTF to metal fuel, thereby utilizing one fuel supply capability for both the EBR-II and the FFTF; the layup of the Secure Automated Fabrication (SAF) line (which is not required because of the conversion of FFTF to metal fuel); the phased shutdown of the 308 Building; and the planned consolidation of FFTF metal fuel assembly activities in the existing and modern Fuel Assembly Annex of the Fuels and Materials Examination Facility.

Answer 11
(continued):

- The shutdown of the Critical Mass Laboratory consistent with completion of program requirements and a Department-wide evaluation indicating no further need.

- The conduct of a study (which was completed in March 1988) between DOE and three local utilities in the Hanford, Washington, area that established the technical and economic feasibility of a privately-financed electrical generating addition to the FFTF. Such an addition would provide revenues to DOE from the sale of steam, as well as LMR steam generator operations and performance data.

- Continuation of closeout activities for the Wing-9 Hot Cell at the Los Alamos National Laboratory furthering the consolidation of irradiation examinations at existing hot cells.

- Increased use of the NE facilities on a cost sharing basis.

- Preparation of a draft Facility Utilization Plan that projects the specific uses of all major NE test facilities through FY 1996. This plan will be

Answer 11 (continued): periodically updated to reflect congressional actions and current DOE planning.

- o Preparation for initiation of a program with universities and industry to capitalize on the unique resources offered by the EBR-II complex to attract, train, and utilize young, promising talent in all aspects of the reactor systems, fuel manufacturing, fuel processing, and waste treatment.

DOE continues to examine, on an ongoing basis, possible areas for further facility consolidation and economies. Also, DOE is studying the potential to utilize the FFTF for other DOE missions.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 12: What is the current mission of the Fast Flux Test Facility (FFTF)? What will that get us?

Answer: The FFTF is currently utilized to conduct prototype fuels and materials irradiations in support of the Department's Advanced Reactor Research and Development program including international agreements and the Space and Defense Power Systems program. FFTF is also being used to irradiate candidate materials for the Energy Research fusion program and occasionally for production of isotopes for medical and industrial uses. DOE is currently evaluating additional FFTF missions to more effectively accomplish DOE's objectives.

In the near term, the ongoing testing efforts in FFTF provide needed fuels and materials performance data and design verification results in support of the aforementioned programs. In the longer term, our latest and most modern irradiation facility will be utilized to safely and cost-effectively accomplish assigned Department programs.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 13: What is the current mission of Experimental Breeder Reactor (EBR)-II? What will that get us? Do we need both Fast Flux Test Facility (FFTF) and EBR-II?

Answer: The current mission is to develop and operate the EBR-II complex as a prototype Integral Fast Reactor (IFR) system, including safety tests to demonstrate enhanced passive safety capabilities. In addition, irradiation experiments are being conducted to support the Space and Defense Power Systems program and international agreements as part of the LMR program.

EBR-II operation in conjunction with reprocessing, refabrication, and waste treatment of EBR-II spent fuel will enable the development and demonstration of the technology and safety for the metal fuel cycle for the IFR system. This will provide the technical basis for future advanced LMR's.

As stated in this answer and the answer to the previous question on the FFTF, these facilities provide unique capabilities and fulfill different mission needs of the Department.

QUESTIONS FROM SENATOR JOHNSTON

NUCLEAR REACTOR R&D

Question 14: What does the term "passive safety system" mean? Is there really such a thing as an "inherently safe reactor"?

Answer: The term "passive safety system" refers to reactor systems that perform a safety function without dependence on active components (such as pumps, valves, electric supply) or operator actions. The most important passive systems in the advanced reactor designs are those that assure reactor shutdown and removal of residual heat.

These systems operate using "inherent" laws of nature that cannot be defeated; e.g., gravity, thermal expansion, and buoyancy. For example, reactor shutdown could be achieved through the expansion of reactor core components, fuel, control rods, and related structures, which change the core configuration to the point that a nuclear chain reaction cannot be sustained. This capability has been demonstrated at the Experimental Breeder Reactor II at the Idaho National Engineering Laboratory. Heat removal is accomplished through the natural circulation (hot fluids rising without pumping) of sodium coolant inside the reactor vessel and air on the outside of the reactor vessel. These passive functions occur regardless of operator action or inaction. A reactor with these passive capabilities is sometimes referred to as an

Answer 14
(continued): "inherently safe reactor." This term is not meant to imply that the reactor is fail safe; however, the use of passive systems that rely on inherent laws of nature provide reactor designs with very high safety margins and extremely low probabilities of failure.

QUESTIONS FROM SENATOR HECHT

NUCLEAR REACTOR R&D

Question 1: What research is the Department doing on light water reactor technology or fuel fabrication technology that will allow existing or new light water reactors of conventional design to transmute transuranic waste? How much money has the Department budgeted for this work in FY 1989? What additional work of what importance could be done if the FY 1989 appropriation were 10% higher than in the President's budget?

Answer: The Department presently is doing no research that is specifically directed towards developing light water reactor technology or fuel fabrication technology that would allow existing or new light water reactors to transmute transuranic waste and has not budgeted any FY 1989 funds in its light water reactor program for such research. If additional FY 1989 funds were appropriated by the Congress for the light water reactor program, they would be applied to accelerating the development of simpler mid-size advanced LWR's utilizing passive safety features.

QUESTIONS FROM SENATOR HECHT

NUCLEAR REACTOR R&D

Question 2: What research is the Department proposing to do in FY 1989 with regard to the Sodium Advanced Fast Reactor (SAFR), a waste burner for light water reactor waste? How much money has the Department budgeted for this work in FY 1989, and what additional work could occur if the FY 1989 appropriation were 10 percent above the President's request for this work?

Answer: The Sodium Advanced Fast Reactor (SAFR) being developed by Rockwell International (RI) is one of two advanced Liquid Metal Reactor (LMR) designs being developed by the Department. The primary objective of the SAFR program is to develop a design with high safety margins, through use of passive safety systems, and economics competitive with other contemporary electricity producing sources. The SAFR is not specifically designed to burn LWR wastes. Although, the LMR does have a unique capability because of its fast neutron spectrum to burn long-lived waste products from LWR plants, the FY 1989 budget as submitted does not include funding for a waste burner using SAFR or any other advanced LMR.

If funding was provided in FY 1989 specifically to investigate this waste burning capability of LMRs, the concept feasibility studies begun in FY 1988 at the Oak Ridge National Laboratory, Argonne National Laboratory, and Westinghouse Hanford Company for actinide burning would be

Answer 2
(continued): extended. Laboratory-scale tests of key actinide/fission product separation would be initiated to confirm the efficiency and economics of the proposed processes. However, a general 10 percent increase in Advanced Reactor R&D funding would be applied to other higher priority tasks.

QUESTIONS FROM SENATOR HECHT

NUCLEAR REACTOR R&D

Question 3: What other work is the Department doing on technology to burn light water reactor waste, and how much money is budgeted for this work in FY 1989?

Answer: Small feasibility studies are in progress to define fuel cycle options for burning LWR spent fuel in advanced LMRs. These studies are carried out at Argonne National Laboratory, Oak Ridge National Laboratory, and Westinghouse Hanford Company with a total funding of $150,000 in FY 1988.

No funding has been requested for technology to burn light water reactor waste in FY 1989.

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QUESTIONS FROM SENATOR HECHT

NUCLEAR REACTOR R&D

Question 4: Please indicate whether there is any research of which you are aware on how fission product waste may be destroyed through waste burner technology?

Answer: The destruction of nuclear waste by transmutation has been considered by Westinghouse, Argonne National Laboratory, Brookhaven National Laboratory, Oak Ridge National Laboratory, General Electric and many other organizations over the past 25 years. Some of these studies were supported by DOE and its predecessor organizations. Presently, we are aware of a cooperative Japanese/German program supporting this technology which includes some research.

QUESTIONS FROM SENATOR HECHT

NUCLEAR REACTOR R&D

Question 5: How is the Department keeping abreast of research being done abroad on waste burner technology? What countries have done the most research in this area? What countries have done the best research in this area?

Answer: International conferences provide exchanges of information with other countries. Several countries have studied the problems involved. The U.S. has published the most work in this area, and we believe the U.S. has done the most research on the technical issues involved. We would characterize most of the work to date in Japan, Germany and the United Kingdom as feasibility studies. The work is all of good quality.

QUESTIONS FROM SENATOR HECHT

NUCLEAR REACTOR R&D

Question 6: If waste-burner technology can be perfected to eliminate transuranic waste, wouldn't this eliminate the need for a repository? Couldn't any short-lived fission product waste that couldn't also be transmuted, be simply stored above ground in a MRS-type facility for the fifty years or so required for them to decay to relatively safe levels?

Answer: It seems likely that short-lived fission products could be safely stored above ground until they decay to relatively safe levels. The acceptability of such procedures would depend on the successful development of partitioning processes to remove the actinides, as well as the development of appropriate facilities to safely store the fission products.

The Nuclear Waste Policy Act directs the Department to develop geologic repositories for the disposal of nuclear spent fuel and high-level radioactive waste. Further, R&D on waste-burner technology is in the embryonic stage and any ultimate application would be well beyond the year 2000. Hence, a geologic repository will definitely be required.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 7: Within DOE, Defense Programs is considering the MHTGR as a candidate for the New Production Reactor (NPR) which will be required in the late 1990's. Similarly, DOE's Nuclear Energy progress has embarked on a design and licensing effort for a commercial HTGR. Would it not be appropriate for DP and NE to coordinate their efforts? Wouldn't this maximize our payback on reactor development by providing the U.S. with a modern, reliable system for defense materials production as well as the option for an advanced plant for commercial electrical generation?

Answer: If the modular High Temperature Gas Reactor (HTGR) concept is chosen by the Office of Defense Programs for the New Production Reactor (NPR), it would be appropriate to coordinate the design of this reactor with that of the ongoing R&D on the civilian modular HTGR. Use of HTGR technology for a production reactor would provide an additional demonstration of HTGR technology and thereby provide an enhanced basis for commercial assessment. However, because these applications differ widely, use of HTGR technology in a production reactor would not provide the demonstration of commercial viability necessary to satisfy the expectations of the public, the investors and the industry.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 8: While assuring our domestic energy supplies is the paramount objective, the U.S. balance of trade will require that we have new exportable technologies and goods. Shouldn't our advanced reactor development policy give strong consideration to the exportability and total world market available to the nuclear technology to be demonstrated?

Answer: The promotion of foreign interest in U.S. advanced reactor designs has been a goal of the advanced reactor program both from a standpoint of sharing costs and developing market interest. The advanced reactor designers have had numerous interactions with foreign entities; particular interest in these designs has been expressed by Japan, Germany, and Italy. A number of foreign companies are already cooperating in the U.S. advanced reactor program. Our advanced reactor development policy should continue to give strong consideration to the exportability of these advanced designs.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 9: Nuclear power has made an increasingly important contribution to electrical generating needs in the U.S. and several other countries. While continuing to expand nuclear electrical production will reduce oil and natural gas consumption and help reduce CO(2) (green house) and acid rain concerns; a higher temperature nuclear energy source will be required if nuclear is to contribute to the much larger industrial process heat market. In the longer term, such a high temperature heat source could also be used for coal gasification and other synthetic and portable fuel production. Should our advanced reactor development policy give strong consideration to advanced reactors which can provide process heat, as well as electricity?

Answer: The HTGR is unique with regard to its high temperature characteristics and potential for providing industrial-grade process heat as well as electricity. While this capability is one benefit of the modular HTGR and should be given consideration, it is not the only criterion in our reactor development policy by which advanced reactor technologies should be judged. The advanced LMR, for example, is unique with regard to its capability to extend available uranium resources. This is another consideration in our advanced reactor development policy. Further, the HTGR and LMR are both projected to provide electricity at competitive costs using simple passively safe designs with very high safety margins.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 10: In recent years, Congress has demonstrated consistently strong support for the Modular HTGR. Why is DOE so resistant to accelerating the MHTGR design and initial project in response to this support?

Answer: In FY 1989, $7.7 million is requested to maintain the technology base for the HTGR, primarily through international collaboration, pending completion of design review by the Nuclear Regulatory Commission and subsequent understanding and resolution of safety issues. It is prudent to delay further expenditure of significant R&D funds until ultimate licensability of the modular HTGR concept is better defined.

QUESTIONS FROM SENATOR MCCLURE

SPACE AND DEFENSE

Question 11: As you probably already know, I am extremely supportive of DOE's research in space and defense power systems. This is an area where nuclear power will clearly be filling a need that no other technology can match. I am, however, deeply concerned that the ramping up of this program will have a detrimental effort on the civilian reactor research program. We already see this happening in the '89 budget request: the space/defense power systems budget request is up by $32 million, and the civilian programs have been reduced by almost exactly that same amount. This is not acceptable to me. Any increase in space/defense systems must be incremental to the civilian program. Furthermore, since the space/defense programs have ultimate "users" (NASA and/or DOD), I would think that user fees should fill in this gap, rather than taking it from the hide of the already lean civilian program. Do you care to comment?

Answer: The Department believes that the fiscal year 1989 budget request strikes a reasonable balance, within existing resource constraints, among several high priority programs including civilian reactor development and space and defense power systems. We believe that the objectives of each program can be met on a reasonable schedule with the requested funding. Within this context, the pace (and therefore the funding requirements) of the space and defense program is established largely by the need to support user agencies in their mission requirements, i.e., by the need to develop various power technologies by the dates required by the users. The users, in turn, fund the development of these technologies, pooling their resources with DOE, and generally paying about half the cost of each program.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 12: How much money is DOE planning to spend on the large, advanced LWR work? How much on the 600 MWe plant? How does the Department counter criticisms that the LWR industry is sufficiently mature that it ought not to receive any federal assistance? Since the 600 MWe plant size is more likely to fit into the capacity planning schemes of most U.S. utilities, why is work on the larger plants being pursued at all? Who is likely to order the larger-sized plant?

Answer: Funding of $6.5 million in FY 89 is planned in support of Design Certification of large advanced LWR's by the NRC under their Standard Plant Licensing Policy.

It is difficult to characterize the U.S. LWR industry as not deserving of continued federal support since no new plants have been ordered in the last 10 years. Current U.S. LWRs provide electricity equivalent to about 2 million barrels of oil per day. Worldwide, LWRs supplant about 8 million barrels of oil per day. It is important, therefore, to bring forward a new generation of nuclear technology that meets the needs of the nation at a time when the institutional environment does not favor large, capital-intensive projects such as coal or nuclear powerplants. The LWR is similar to clean coal technology in that they are environmentally benign and both need Federal support to bring this technology forward for market consideration.

Answer 12
(continued): The certification process of the large advanced LWR's is taking place in parallel with NRC's development of certification and standardization policy and procedures. The advanced LWR certification is thereby the vehicle for implementation of this policy; the demonstration of regulatory predictability which will result is necessary for all types of advanced reactors. In addition to serving as a vehicle for implementation of NRC's standardization policy, the plants will be available as options for standard plants in the 1990's.

The large advanced LWR's being certified represent the best LWR technology available worldwide; success in certification will make them available in the United States. Many utilities are of a size such that they might prefer these plants; other smaller utilities might prefer to await completion of development of smaller plants.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 13: In your testimony, you state what is obvious, that is, that introduction of advanced reactor technologies into the market place depends on the attractiveness of the technology to utilities and to the public. What forum do you use to get utilities and the public to weigh in on these matters?

Answer: At the present time, domestic utilities are not buying large capacity additions for their utility grids, and so it is difficult to establish any strong utility financial commitment to a new project based on advanced reactor designs. Nevertheless, the reactor designers for the advanced LMR and HTGR have utilized utility panels to review designs, follow progress, and provide input from a utility point of view, including future market potential. Their strategy has been to get utility involvement at an early stage of design so that utility representatives are familiar with their designs and will hopefully consider them in their decision process for future plants.

DOE maintains interfaces with the Electric Power Research Institute (EPRI), who represents a large number of domestic utilities. Efforts conducted with EPRI include advanced reactor studies, review of DOE advanced designs by EPRI-established utility panels, and review of program plans by EPRI and utility panels. With regard to interactions with

Answer 13
(continued): the public, videotapes and information booklets have been prepared by the advanced reactor vendors for dissemination. A program is also in place to visit universities and provide presentations on simple, passively safe advanced reactors designs and their capability with regard to improved safety margins and competitive economics.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 14: How much international interest is there in the extended-life oxide core work being done at FFTF? How much money is being contributed by foreign parties?

Answer: There are essentially two programs underway at FFTF aimed at extending the lifetime of oxide cores:

1. Core Demonstration Experiment (CDE).

2. Materials and oxide fuel assembly tests in support of an agreement with Japan.

There is only modest international interest in the CDE. which is supported exclusively with DOE funds. Oxide fuel in the CDE experiment is clad with a ferritic alloy (HT-9), and the foreign community favors cladding with higher temperature strength material because foreign reactor designs have higher reactor outlet operating temperatures than U.S. designs.

Phase I of a Fuels and Materials Agreement with Japan is aimed at extending the lifetime of oxide cores utilizing an advanced cladding alloy (dispersioned strengthened ferritic) which provides added strength at the higher operating

Answer 14
(continued): temperatures favored by the foreign community. Japan has contributed $1.1 million for extended lifetime testing in FFTF. A second phase of this agreement is under review by Japan and, if implemented, would provide an additional $27.0 million over an 8-year period for extended oxide fuel lifetime testing with high temperature strength cladding material. Other foreign countries (Germany, France, England and Russia) have interest in this type of work but are pursuing tests in their own reactors.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 15: How much international interest is being shown on Argonne's Integral Fast Reactor (IFR) program? When will the IFR fuel cycle demonstration be completed?

Answer: The Japanese breeder reactor program has shown the most active interest in the Integral Fast Reactor (IFR) program. For the past year, the IFR has been a central area of negotiation between the Department and the Japanese with regard to achieving a comprehensive cooperative program. The IFR program has also been presented to representatives of the European and Russian breeder reactor communities. While interest in following the IFR program was expressed, their programs, with large capital investments in place, are heavily committed to a mixed oxide fuel cycle.

The IFR fuel cycle demonstration in the Experimental Breeder Reactor II (EBR-II) will consist of three main areas. First, the fuel recycle demonstration phase (reprocessing and fabrication) will be initiated in the Hot Fuel Examination Facility - South (HFEF-S) in FY 1991 and will be completed about 1 year later. The HFEF-S operation will provide a full fuel recycle service for EBR-II driver and test fuel. Second, recycle fuel performance testing will begin about mid-FY 1991 and will continue through FY 1993. Third, an inherent safety demonstration with recycle fuel in EBR-II is

Answer 15
(continued): scheduled to be completed in FY 1992 to verify the reactivity control features inherent in metal fuel.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 16: Comparatively speaking, how mature are the advanced LWR designs compared to the modular HTGR design? How much additional time would be required to bring these designs to the point where a prototype plant could be constructed?

Answer: Over 100 light water reactor power plants are currently in operation in this country. The advanced LWR designs build on lessons learned from this extensive operating experience--both good and bad--to incorporate significant improvements and simplifications in plant systems, design features, and configurations. These advanced designs apply to the latest proven technology, but retain the fundamental design concepts proven by many years of service. Therefore, the advanced LWR designs involve much less technological and investment risk than more revolutionary designs.

The Department has been working jointly with the nuclear industry on the development of both large (greater than 1000 MWe) and mid-size (approximately 600 MWe) advanced light water reactors. Design certification by the Nuclear Regulatory Commission of the large size plants is targeted for 1991, and for the mid-size plants by 1995. Conceptual design of the advanced modular High Temperature Gas Reactor (HTGR) was completed in FY 1987, and preliminary design activities were initiated in FY 1988. If adequate funding is provided, a design of a standardized modular HTGR could be

Answer 16
(continued): completed by 1994. With private sector support, the completion of design could be expedited. Whether Government or industrial sector funding is provided for design, construction of a demonstration plant will be the responsibility of the private sector.

QUESTIONS FROM SENATOR MCCLURE

NUCLEAR REACTOR R&D

Question 17: **How much revenue does DOE expect to receive annually from the sale of steam at FFTF following completion of the "Power-Pac" addition? How does this compare with the annual operating costs of FFTF?**

Answer: We expect that DOE would receive between $7 and $10 million annually from the sale of steam upon completion of a privately financed power addition. In the FY 1989 budget, $63.0 million is requested for the overall Westinghouse Hanford Company operations, which includes $5.5 million in cost sharing to be provided by the Space and Defense Power Systems Program. The Department is considering providing up to $17 million in additional funding in FY 1989, for a total of $80 million.

QUESTIONS FROM SENATOR SASSER

NUCLEAR REACTOR R&D

Question 18: I have some comments regarding the Oak Ridge research reactors. As a general point, I would like to inform DOE that I would like to see HFIR, the Tower Shielding Reactor, and the other reactors at Oak Ridge up and running as soon as the appropriate procedural and other necessary changes have been completed. I also want the Advanced Neutron Source program to proceed at a vigorous pace. I am disturbed that there is evidently some talk within DOE about relocating some of these reactor programs, such as our joint program with Japan on shielding, to other DOE facilities. I strongly oppose such a move. The Oak Ridge reactors provide the United States with many important and unique capabilities.

I am particularly concerned about the way DOE is handling its decision-making on the Tower Shielding Reactor. Recently, our office heard that DOE had decided to shut down that reactor permanently and that the Japanese shielding program would not proceed. Now we hear that DOE is suggesting that this work be moved. I am very concerned about the way in which this matter has been handled. First we were told the program was going to be terminated. Then we find that it is simply a move to shift the work elsewhere. As I have previously stated, the tower facility is unique and is currently the central experimental facility for the joint shielding program which is co-funded by the Japanese. Their breeder program and, potentially, all of our reactor programs, stand to benefit from improved shielding.

I would appreciate a written response from the Assistant Secretary for Nuclear Energy or other appropriate DOE program managers regarding the status of the reactor program at Oak Ridge, with particular emphasis on the issues I have raised.

Answer: Within the Office of Nuclear Energy, the requested FY 1989 Advanced Reactor R&D support for the Oak Ridge National Laboratory is $9,256,000. These funds are allocated to the following activities:

Answer 18
(continued):

1. Support of High Temperature Gas Reactor (HTGR) technology: $3,156,000.

2. Reliability data base development (CREDO), which is jointly supported with Japan: $200,000.

3. Collaborative reprocessing development program with Japan: $5,000,000.

4. Tower Shielding Facility: $900,000.

The initial decision to shutdown the Tower Shielding Facility (TSF) was made by the Manager of the Oak Ridge Operations Office in the Spring of 1987. Substantial upgrades were identified as necessary before a restart of the TSF could be considered. Some months ago it became evident that substantial, further, delays would be encountered. Given the existing fiscal constraints, and the lack of any certainty on when the facility might be able to restart or on the costs still to be borne, the Office of Nuclear Energy directed that the plans be made for permanent shutdown of the TSF. Options were explored on how best to handle the joint shielding program co-funded with the Japanese. The possibility was

Answer 18
(continued): investigated of completing this program at another DOE facility, but this was not attractive to the Japanese.

A final decision on whether permanent shutdown versus resuming operation of the TSF will be made sometime within the next several months based upon cost and programmatic considerations, which must include assurance of the safe operation of the TSF. The overall decision process is reasonable given the circumstances.

With respect to your comments regarding other Oak Ridge research reactors, steps are being taken to permit restart and safe operation of those facilities necessary to support the Department's missions.

AMERICAN NUCLEAR ENERGY COUNCIL

Kevin W. Billings
Vice President

June 10, 1988

The Honorable Wendell H. Ford
Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed are the responses to the questions included in your May 25th letter to James J. O'Connor.

Sincerely,

Kevin W. Billings

Enclosure

410 First Street, SE, Washington, DC 20003 (202) 484-2670

JAMES J. O'CONNOR
Chairman and Chief Executive Officer
Commonwealth Edison Company

Responses to Follow-Up Questions From Sen. Bennett Johnston

Question

Right now, utilities are not at all interested in building new central power stations and they are instead buying from small power producers and cogenerators. How long do you believe this trend can continue?

Answer

The trend will continue as long as the electric utility industry is penalized—as it has been—for investing in new, baseload power stations. Recent history is replete with examples of companies that have built new power plants but have not been allowed to recover the cost of new plant construction, and of companies subjected to retrospective examinations of their prudence in having built new capacity. And in two cases—Shoreham and Seabrook—state governments have been holding up emergency plans to keep needed plants from operating. The wildly uncertain regulatory climate in which electric utilities now operate has a chilling effect on new investment—and that chill will continue.

Those obstacles must be overcome before new baseload power plants—with long lead-times, high capital cost but low energy cost—will be built. Exactly when, I don't know.

Question

Won't it soon be necessary for utilities to go back to building central power stations?

Answer

Personally, I believe it is already past time in some parts of the U.S. for utilities to start building new coal-fired or nuclear electric plants. We already see clear evidence that availability of adequate supplies of electric energy is a problem in New England, and that much of the rest of the eastern seaboard is close behind.

Nationally, we have no shortage of danger signs. The electric power industry—regulated utilities and small power producers—is building to meet electric demand growth of about 2 percent a year. Since 1982, electrical sales growth has averaged 3.3 percent a year. Last year sales were 4.5 percent above the previous year, and so far this year sales are running more than five percent higher than last year as our manufacturing sector recovered. Construction has not yet started on almost 45 percent of the 90,000 megawatts of new generating capacity expected to be needed by 1996. Clearly, the U.S. is perilously close to outrunning its electricity supplies.

Logic and common sense indicate that America's electric utilities should be building new coal-fired and nuclear electric power plants, which produce electricity at least cost over the long pull. They are not doing so, because of the disincentives listed above. Instead, the power companies are being forced to rely on units that can be built cheaply and quickly—combustion turbines fueled with natural gas and oil. These units offer the lowest "up-front" capital cost, but their long-term economics are vulnerable to fluctuations in the availability and price of oil and gas.

Question

What will it take to get a utility to build a new central station?

Answer

Before electric utilities will build new coal-fired or nuclear electric power plants, they need greater certainty with respect to both licensing and return of and on their investments in such facilities.

In the case of nuclear plants, utilities must be assured that they will be allowed to operate the plant when it is completed and built as originally approved—not held up by the refusal of states or local government to participate in emergency plans.

Also in the case of nuclear plants, electric utilities must see reform of today's licensing process. The industry is doing its part to standardize its nuclear plant designs. Congress can help by reforming the licensing process. Once a standard design is certified as safe by the Nuclear Regulatory Commission, utilities require an assurance that, if they build the plant as specified, they will be allowed to operate it without major new hearings. Today's two-step licensing process is too subject to delay, needless litigation, manipulation and uncertainty to serve our future needs.

And in the case of coal and nuclear plants, with their high front-end capital costs, utilities must have assurance that they will be allowed to recover their investment and given a reasonable opportunity to earn their allowed rate of return on that investment. What is needed is a more constructive approach to utility rate regulation that avoids the punishing, retrospective reviews of plant investment that have become commonplace in recent years.

Question

Do you think a single utility will be willing to be the pioneer in building the next new nuclear plant?

Answer

If we can solve the institutional uncertainties that have crippled new baseload generating capacity, I see no reason why a single utility—assuming it had the need for power—would not seriously consider building a new nuclear plant. In practice, most utilities are not large enough to absorb that much capacity all at once and may not feel they have the necessary technical resources. Therefore, I would expect that some future plants would be built by consortia of utility companies. Many of our existing plants were built in this fashion, with ownership of the plant divided among several companies. But that too will require mutual agreement with several state commissions.

Question

Commonwealth Edison has been a pioneer in the nuclear area in the past. Would Commonwealth be willing to build the first advanced light water reactor?

Answer

Again, assuming the institutional uncertainties are resolved favorably, I see no reason why Commonwealth Edison would not give consideration to an advanced LWR as an option to meet future growth in demand.

Question

Would you be willing to build the first HTGR or liquid metal reactor?

Answer

If the high temperature gas reactor and liquid metal reactor are the economical choice, if they have demonstrated the reliability and availability required for commercial utility service, and if they are certified by the NRC for licensability, then we would consider them. But a utility must have confidence in a new technology--nuclear or coal--before building a plant. In the case of HTGRs and LMRs, I believe that confidence will require more development and demonstration than evolutionary light water reactors. So their application is still some years away.

As you know, Commonwealth Edison played a leading role in the Breeder Reactor Corporation, which represented the utility industry's interests in the cancelled Clinch River project, a 300-megawatt demonstration of liquid metal technology. Our interest in proving out advanced reactor concepts is a matter of record and still stands.

Question

What would be required for any utility to take such a step? A fixed cost contract for construction and services? Assurances of support from the state PUC, or even a request from the PUC to build a new plant? Advance certification of design from NRC?

Answer

As noted above, to build a liquid metal reactor or a gas-cooled reactor, a utility must have assurance that the plant will meet high standards of reliability, availability and be economical. Fixed price contracts for construction, even with extended warranties, are not much help if the plant is often out of service for any reason. As a utility, we have an obligation to serve and we would not gamble with our customers' expectations that the electricity will be there when they need it.

Assurances of support from state regulators would be absolutely essential--not only for construction of advanced reactor types, but for construction of any new baseload power plant--nuclear or coal, advanced or otherwise.

Advance certification of nuclear plant designs by the NRC is also vital. This is true for advanced light water reactors, liquid metal reactors and gas-cooled systems.

Question

Should there be a demonstration of one of the three reactor systems?

Answer

As you know, there are at least three advanced nuclear systems.

The electric power industry is aggressively pursuing two approaches to the advanced light water reactor. One involves large plants in the 900–1,300–megawatt range; the other involves smaller plants in the 600–megawatt range. Both approaches build on a base of 30 years experience with light water technology and I am confident that, if we can resolve the institutional problems, electric utilities would be able to deploy these technologies without requiring an intermediate demonstration step. In fact, Tokyo Electric Power Company has already ordered two advanced boiling water reactors from General Electric with Hitachi and Toshiba heavily involved.

In the case of liquid metal and gas–cooled plants, I believe prototype demonstration plants will be required to establish the necessary level of confidence to warrant consideration for use on utility systems.

U.S. experience with high–temperature gas reactors—at the Fort St. Vrain plant in Colorado—does not provide the confidence required to jump directly to a full–scale commercial plant. And although our experience with liquid metal plants has been favorable, our two test facilities—EBR–2 and the Fast Flux Test Facility—are relatively small (about 20 megawatts and 100 megawatts, respectively). Also, the experience with liquid metal reactors overseas has been encouraging.

Utility requirements for high reliability and high availability dictate a prudent approach to deployment of new technology. There is much to be learned about the performance of a reactor and its hundreds of components in the process of scaling up from small sizes to large. I believe history demonstrates that we leave ourselves vulnerable to failure when we attempt to push a new technology too far too fast.

I also believe this applies to all power generation technology—combustion turbines, gasifiers and fluidized bed boilers just as much as nuclear systems. In the case of atmospheric fluidized bed boilers, for example, the Electric Power Research Institute's development program started with a 20–megawatt prototype, moved next to a 200–megawatt demonstration, and will ascend from there to commercial scale.

Question

Should the federal government support such a demonstration?

Answer

As you know, the Department of Energy is already supporting R&D on all three advanced systems—light water, gas and liquid metal—to varying degrees. I earnestly hope that support will continue.

As things stand now, I believe it would be premature to establish a definitive schedule for building a demonstration plant.

Deciding when and if to build a demonstration plant, and which technologies should be demonstrated, is a question that should be decided by the entire community with a stake in the decision—the government, the reactor manufacturers and the electric utilities. Of these three, perhaps the most important is the utility industry, which will probably build, finance and operate the plants.

The decision to build a demonstration reactor should also take account of many other factors—including (but not limited to) the status of development; the maturity of the technology; the economic outlook for the technology; the degree of cost-sharing and risk-sharing that can be secured; whether the technology developer is willing to commit development effort and funds; the extent of the infrastructure (fuel cycle, component development) available to support the new technology, and so forth. Demonstrating a new reactor type is a complex decision. And it requires full involvement of the commercial organizations that would have follow-on responsibility.

One factor should certainly not play a role in this decision—and that is the technology developer's skill at "selling" his concept at the expense of others.

One final point: any demonstration plant must be licensed and certified by the Nuclear Regulatory Commission. Demonstrating a new technology's licensability is fully as important as demonstrating its technical performance.

Question

Would the utilities and industry be willing to go in on a 50-50 cost-sharing arrangement?

Answer

It is far too early to settle on the level of cost-sharing that might be obtained for a demonstration plant. I believe that the utility industry, at some time in the future, would be willing to contribute financially or in-kind to a soundly conceived demonstration project. This industry has contributed to the Clinch River breeder reactor demonstration project, to the demonstration of integrated gasification combined cycle technology and to the demonstration of atmospheric fluidized bed technology, among others. Also, both LMR design proposals recently submitted to DOE by General Electric and Rockwell include construction of prototype plants. These proposals contemplate substantial industry cost-sharing and, in fact, include the repayment of all government funds from the revenues produced by the project's sale of electricity.

Electric utilities today are not in the same financial position they once were. And the supply industry does not perceive the same market opportunities that they once saw, so they are more reluctant to make investments. Demonstration of these systems in today's utility environment would have to be funded principally from government sources.

Question

Is there a clear near-term option of choice for the next reactor order, or next generation of reactors?

Answer

The next nuclear plant ordered in the U.S. will undoubtedly be an advanced light water reactor, probably the "evolutionary" plant in the 900-1,300 megawatt range if, as I believe, the order is placed within the next decade. These plants are similar to today's plants but include a number of modifications/simplifications that offer increased operating margins, improved reliability and component performance, and make maintenance easier. Within that same period or shortly after that, assuming the development program proceeds as expected, I would expect to see the first orders for the 600-megawatt-range light water reactors that employ various so-called "passive safety" features.

Question

Realistically, how far into the future is the next reactor order?

Answer

The timing of the next reactor order is largely out of the utility industry's hands. It depends on how quickly Congress acts to reform the nuclear plant licensing process and on prompt resolution of the other institutional uncertainties that preclude the utilities' consideration of high-capital-cost generating options today.

One thing is certain: in some parts of the country, the need for new electric plants exists today. If we do not see orders for new capacity by the early 1990s, I believe this country faces a bleak and uncertain economic future—given the intimate relationship between economic growth and reliable supplies of electric power.

I believe the next orders for nuclear plants could be placed by the mid-1990s.

Question

Realistically, in what time frame would a utility build a liquid metal reactor or HTGR?

Answer

I do not know when a liquid metal or high temperature gas reactor might be ordered. That depends on R&D progress and successful demonstration of the technology at significant power levels. Assuming development programs now underway are successful, and that these designs are demonstrated to have significant advantages in safety, economics and reliability over the light water reactor, utilities could start ordering these plants early in the next century. The critical pacing item is not utility willingness to build LMRs or HTGRs. The critical item is the readiness of the technology to be deployed. Even if we were to start building a demonstration LMR or HTGR tomorrow—and I am not persuaded we are ready technically to take that step—it would be the late-1990s before that project would be built, licensed and ready to operate. Then we would need at least a 4-5 year test program to demonstrate that the technology is sufficiently reliable to qualify for commercial service. That puts us past the year 2000.

Question

Under what circumstances and on what terms would a utility build an LMR or an HTGR?

Answer

To build an LMR or HTGR, a utility would require convincing demonstration that such a plant would really have significant advantages over light water reactors and that there is a commercial infrastructure (suppliers of equipment and services) to support the technology.

Question

Is legislation necessary to focus the Department of Energy's R&D program? In your view, what would be the essential pieces of such legislation?

Answer

The single most important consideration is to formulate common goals that are shared by the government and the utilities that will use this technology, then establish a stable, appropriately funded R&D program to achieve those goals. We are dealing here with development programs that necessarily span 10 or 15 years between conception and completion. Instability is the main threat to the success of such development programs. We need to set a reasonable course with reasonable milestones, and then stick to it. If new legislation is necessary to set that course, I would support it.

Question

Would the clean coal demonstration program be a good model?

Answer

Yes, in the sense that it indicates a commitment to a long-term research and development program.

JAMES O'CONNOR, Commonwealth Edison Co.

Responses To Questions From Sen. James McClure

Question

You all adhere to the philosophy that the next nuclear plant that a utility will order will be a light water reactor design. While you may be correct, this does not answer the question of where the federal emphasis ought to be placed. I could argue that, since the LWR technology is a mature industry, federal involvement in the development of advanced LWR designs is inappropriate, and the only federal role that might be justified is with respect to some of the institutional reforms that I mentioned in my opening statement. Would you agree with this?

Answer

Institutional reforms—in federal nuclear licensing and state economic regulation—are absolutely vital to the future expansion of nuclear energy in the U.S.—no matter what the reactor concept. These reforms should have the greater Congressional priority.

I agree that large-scale federal involvement in advanced LWR development is not necessary. Successful completion of this effort does, however, require some financial support from the Department of Energy and continuing interaction between the Department of Energy and the Nuclear Regulatory Commission on licensing issues.

Question

The modular high-temperature gas reactor and the liquid metal reactor, on the other hand, are not nearly as "mature" as the LWR in terms of commercial infrastructure. So it would seem entirely appropriate that the government take lead responsibility in bringing these technologies to a state of commercial readiness. Do you agree?

Answer

I agree that the federal government must play a major role in advancing the development of gas-cooled and liquid metal reactors. Market uncertainties preclude large industrial investment in R&D on these concepts. To be successful, a development program must be a partnership among the federal government, the reactor manufacturers, electrical equipment suppliers and the electric utility industry, which will build, finance and operate these plants when they are ready for deployment.

Question

The federal government alone will not make the new technologies happen. What commitment do you think the private sector—that is, utilities and suppliers—ought to be expected to make towards the MHTGR and LMR development programs?

Answer

I agree that the federal government alone cannot commercialize HTGRs and LMRs. The development program must involve the reactor manufacturers, suppliers of equipment and services and the electric utility industry. They should be involved in structuring and operating the program and should provide in-kind support even if they cannot make direct financial contributions.

Question

How do you think capital and operating costs can be best demonstrated with respect to the MHTGR and LMR designs? Will it require actual construction and operation of a prototypical plant? Who should contribute and participate in such an effort?

Answer

The capital and operating costs of gas-cooled and liquid metal reactors will have to be proven with demonstration plants. This program should involve the federal government, the reactor manufacturers, suppliers of equipment and services and the electric utilities. All participants should have a substantial financial stake in the effort, which argues for some kind of cost-sharing arrangement—perhaps in-kind support.

Question

One thing that you all hinted about, and Mr. O'Connor was very specific about, was the timing of introduction of new reactor technologies.

You all agree that advanced LWRs will likely be deployed first. With new baseload capacity needed by the mid 1990s, I would expect that these new designs had better be ready now or certainly very soon, otherwise, they will miss the market opportunity. And if they are nearly ready, this verifies to me that federal support is not needed. Do you care to comment?

Answer

I expect advanced LWR designs to be ready very soon. Design work on the "evolutionary" advanced LWRs (900-1,300 megawatts) has progressed to the point where they are now under certification review by the NRC. Once evolutionary LWRs are certified by the NRC, no further federal support is needed. These designs should be ready for the U.S. market by the mid-1990s.

The smaller (600 megawatt range) advanced LWRs, incorporating various passive safety features, should receive design certification several years later. In this case, federal support is appropriate, especially for R&D related to licensing, although the funding need is relatively modest. Industry will be cost-sharing ALWR development much more heavily than it will support LMR and HTGR development.

Question

You go on to suggest that the minimum threshold of DOE funding for adv. .. ed reactor research (I assume this means HTGR and LMR) should be set at $200 million per year, and I agree that this is a reasonable target. However, you suggest that the utilities won't deploy an HTGR until perhaps the year 2030, and an LMR may not be deployed until the year 2050. If that is the case (and I'm not sure I agree with you at all), are you suggesting that the federal government provide $200 million per year for the next forty-odd years, while we bring these technologies to the development stage? That would be $8 billion worth of funding! We could build several prototypical plants, using advanced reactor concepts that are available today, for a lot less than $8 billion. I guess what I'm trying to say is that I don't think the commercial deployment of these advanced reactors is all that far away, and I don't think it will take $8 billion.

While I am certainly not an expert, I do know that a great deal of the safety and engineering work and the verification tests have been done, and these technologies are closer to commercial viability than you think. In fact, I firmly believe that the modular HTGR and the LMR will be serious contemporary competitors to the advanced LWRs. Do you care to comment?

Answer

I believe that $200 million a year represents a reasonable level of federal funding at the present time for advanced reactor R&D. However, as the U.S. moves toward building demonstration plants, the annual funding requirement may have to increase above this level. When the demonstration plants are built and enter their test and evaluation phase, the annual funding requirement will moderate. The timing of commercial deployment of gas-cooled and liquid metal reactors will be driven by economic, commercial and market considerations. The federal government has never been successful in forcing new technologies into a limited or unprepared market.

I see no basis for believing that gas-cooled reactors and liquid metal designs are "serious contemporary competitors" of advanced light water reactors, especially in view of the enormous amount of operating experience and steadily improving performance of our existing light water reactors. Advanced LWRs will be ready for ordering by U.S. utilities—i.e., certified by the NRC—by 1993 or so. Tokyo Electric Power Co. has already ordered two advanced BWRs, which it plans to have on line by 1996 or 1997. Advanced LWRs are clearly a nearer-term option than HTGRs or LMRs.

Finally, the criteria for commercialization have become much more stringent in recent years. New systems require much more verification of their new features to assure their economic competitiveness, reliability and availability, and licensability. Also, a "one-stop" license for a standardized plant will be required, calling for much more design detail than previously. In the mid-1950s, when these criteria were much less stringent, several LWR power demonstrations were completed before commercialization occurred. Today, financial pressures on the industry prevent the outlay of several billion dollars for full-scale demonstrations.

EPRI
Electric Power
Research Institute

June 10, 1988

The Honorable Wendell H. Ford
Chairman, Subcommittee on Energy
Research and Development
Commmittee on Energy and Natural
Resources
United States Senate
Washington, D.C. 20510-6150

Dear Senator Ford:

In response to your letter of May 25, 1988, which transmitted questions to be answered for the printed hearing record, I am hereby sending my responses.

Sincerely,

John J. Taylor

John J. Taylor
Vice President
Nuclear Division

JJT/ch

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Followup Questions

For John Taylor, Electric Power Research Institute
From Senator Bennett Johnston

Johnston: You seem to indicate in your testimony a belief that all three programs should be kept going and that there should not be a horserace type competition among them.

— What type of funding would this require?

Taylor: Our judgment is that present funding levels in the range or $200 to $250 million annually would be adequate to sustain an effective advanced reactor development program which emphasizes engineering innovation and provides the necessary test program to verify the applicability of new science as well as the merit of innovative features.

Johnston: How would you structure a process for selecting which system to demonstrate?

Taylor: Establish projects for each concept with well-defined goals, milestones, schedules and success criteria. As stated in the report of the Advanced Reactor Development Subpanel of the Energy Research Advisory Board Civilian Nuclear Power Panel (April 1986): "What this technological picture suggests is four tasks, each focused on proving the advanced goals of cost, safety, and proliferation resistance, be pursued so a quantitative comparison of their merits can be made. These four technology tasks are:

o The ultra long-life core, concentrating on oxide fuel (ULLC).

o The LMR metal fuel reactor in an integral reprocessing concept (IFR).

o Innovative liquid-metal-cooled reactor designs, including small modular reactors adaptable to either oxide or metal fuels (Innovative LMR).

o A small, modular gas-cooled system (Modular HTGR).

Each of these four tasks need to be supported by base technology and testing of innovative features and key components, such as steam generators. Thus, a fifth task, a major research and development support task, should be formulated to ensure that the DOE laboratories and test facilities are meeting the needs of the four technology tasks on a timely basis and with a high degree of cost effectiveness.

When an advanced reactor concept meets the success criteria it would be eligible for selection for demonstration when market conditions and institutional reforms make it feasible for the private sector to share financially in the cost of such a demonstration.

Johnston: How much R&D — how many years and how many dollars — would be required before the selection?

Taylor: Since the market and institutional changes are the determining factors, the time scale is difficult to project — it could be in the range of 5 to 10 years and would entail an expenditure of the order of $1 billion to $2 billion.

Johnston: What would be the criteria for selecting a single system for demonstration?

Taylor: Each of the concepts have unique features. The LWR is an electricity-producing workhorse already proven in many utilities in the U.S. and most utilities overseas, whose advanced versions will make it even more so; the HTGR is a converter reactor that can serve as an industrial heat source, as well as an electricity producer which will extend the use of nuclear power to a much broader sector of energy need; the LMR is a fuel producer as well as an electricity producer which will extend the supply of nuclear fuel for generations. Any selection would be based on the following criteria: assured safety and licensability, cost projected to be substantially more attractive than alternate generation, high reliability, simplified designs easy to operate and maintain, and reasonable construction times no longer than 5 years.

Johnston: What is a realistic time schedule for a demonstration?

Taylor: A realistic time scale for a full-scale power plant demonstration is in the range of 10 years from authorization to operation, unless there were a radical shift in priorities and institutional mechanisms which could make the time scale substantially shorter.

Johnston: Should there be a demonstration of one of the 3 reactor systems?

— Should the federal government support such a demonstration?

— Would the utilities and industry be willing to go in on a 50–50 cost sharing arrangement?

Taylor: All of the advanced systems (ALWR, LMR, and HTGR) development programs require demonstration of their innovative features before a full-scale power plant demonstration could be justified. Once that justification has been established, the LMR and MHTGR would require a full scale power plant demonstration; but because of the extensive experience with LWR technology, a full scale power plant demonstration of the ALWR would not be required. The federal government should support such demonstrations, with appropriate cost sharing by the private sector. It is doubtful that the utilities and industry would be in a position under present financial criteria and PUC governance to cost share on LMR and MHTGR demonstrations.

Johnston: Is there a clear near-term option of choice for the next reactor order, or next generation of reactors?

— Isn't the advanced light water reactor likely to be the next reactor built by a utility?

— Realistically, how far into the future is the next reactor order?

Taylor: The near term option of choice is an ALWR of either the evolutionary or passive type. Projections into the future based on existing trends usually turn out to be wrong, but they would indicate about a ten year time frame. Unexpected major changes in conditions, often caused by global upsets, could change these projections either way.

Johnston: Realistically, in what time frame would a utility build a liquid metal reactor or HTGR?

— Under what circumstances, and on what terms?

Taylor: Using as a basis the responses to questions 3 and 5...on the order of 20 years. This assumes a successful full scale demonstration, a market need, and the institutional reforms in place and therefore suggests that a prospective owner/operator would take the authorization step on commercial terms.

Johnston: Is legislation necessary to focus the Department's R&D program?

— In your view, what would be the essential pieces of such legislation?

— Would the clean coal demonstration program be a good model?

Taylor: Legislation would fulfill a vital need: to set the goals as meeting a national need and to provide a stable, long term funding basis for these development programs. The Clean Coal Technology program is a good model if accommodations are made for the longer time frame, a smaller variety of projects, and the greater perceived private sector financial risks in participation in an Advanced Nuclear Technology Program.

Followup Questions

For John Taylor, Electric Power Research Institute
From Senator McClure

McClure:

1. (a) You all adhere to the philosophy that the next nuclear plant that a utility will order will be a light water reactor design. While you may be correct, this does not answer the question of where the Federal emphasis ought to be placed. I could argue that, since the LWR technology is a mature industry, federal involvement in the development of advanced LWR designs is inappropriate, and the only federal role that might be justified is with respect to some of the institutional reforms that I mentioned in my opening statement.

Would you agree with this?

Taylor:

1. (a) Institutional reforms should have the greater Congressional priority. They are essential not only to the LWR but all future nuclear options. Industry should cost share more heavily in the ALWR development and should not require funding of a full scale power demonstration by the federal government. Thus, as is the case today, the lion's share of federal R&D support should be for a LMR and HTGR.

McClure:

1. (b) The modular high-temperature gas reactor and the Liquid Metal Reactor, on the other hand, are not nearly as "mature" as the LWR in terms of commercial infrastructure. So it would seem entirely appropriate that the government take lead responsibility in bringing these technologies to a state of commercial readiness.

Do you agree?

Taylor:

1. (b) I agree.

McClure:

1. (c) The Federal Government alone will not make the new technologies happen. What commitments do you think the

private sector--that is, utilities and suppliers--ought to be expected to make towards the MHTGR and LMR development programs?

Taylor:

1. (c) As noted in my response to Senator Johnston's question, the Federal R&D Program needs to establish projects for each concept with well-defined goals, milestones, schedules and success criteria. These projects are outlined in the report of the Advanced Reactor Development Subpanel of the Energy Research Advisory Board Civilian Nuclear Power Panel (April 1986). After successful completion of these projects and assuming institutional reform and projected market need, it would be appropriate for the private sector to cost share in full-scale power demonstrations of the LMR and MHTGR.

McClure:

2. How do you think capital and operating costs can be best demonstrated with respect to the MHTGR and LMR designs? Will it require actual construction and operation of a prototypical plant? Who should contribute and participate in such an effort?

Taylor:

2. Yes, it likely will require actual construction and operation of MHTGR and LMR prototypical plants. The federal government should support such demonstrations, with appropriate cost sharing by the private sector. It is doubtful that the utilities and industry would be in a position under present financial criteria and PUC governance to cost share on LMR and MHTGR demonstrations.

McClure:

3. One thing that you all hinted about, and Mr. O'Connor was very specific about, was the timing of introduction of new reactor technologies.

   (a) You all agree that advanced LWR's will likely be deployed first. With new baseload capacity needed by the mid 1990's, I would expect that these new designs had better be ready now or certainly very soon, otherwise, they will miss this market opportunity. And if they are nearly ready, this verifies to me that Federal support is not needed. Do you care to comment?

Taylor:

3. (a) Once evolutionary ALWRs are certified by NRC, no further Federal support is needed since they will be ready for

the U.S. market and can serve the time frame of the mid 1990s. The more advanced passive ALWR would take until the mid 1990s to obtain NRC certification and serve a longer time frame. As such, Federal support is appropriate with recognition that Federal funding is relatively modest and that industry will be cost sharing the ALWR development to a heavier degree than the LMR and HTGR.

McClure:

3. (b) You go on to suggest that the minimum threshold of DOE funding for advanced reactor research (I assume this means HTGR and LMR) should be set at $200 million per year, and I agree that this is a reasonable target. However, you suggest that the utilities won't deploy until the year 2050. If that is the case (and I'm not sure I agree with you at all), are you suggesting that the Federal Government provide $200 million per year for the next forty-odd years, while we briefing these technologies to the deployment stage? That would be $8 billion worth of funding! We could build several prototypical plants, using advanced reactor concepts that are available today, for a lot less than $8 billion. I guess what I'm trying to say is that I don't think the commercial deployment of these advanced reactors is all that far away, and I don't think it will take $8 billion.

While I am certainly not an expert, I do know that a great deal of the safety and engineering work and the verification tests have been done, and these technologies are closer to commercial viability than you think. In fact, I firmly believe that the modular HTGR and the LMR will be serious contemporary competitors to the advance LWR's. Do you care to comment?

Taylor:

3. (b) I believe each of the advanced concepts should be available for use on commercial terms on the order of 20 years at a cost of roughly $2 billion. As noted in the report of the ERAB Advanced Reactor Development Subpanel: "A recent EPRI breeder cost-benefit analysis applied to various electricity demand scenarios and varying assumptions on costs and discount rates results in a possible present worth 'net benefit' to the nation of tens of billions of dollars. Thus, $200 million per year of R&D support invested in the recommended advanced reactor program can be considered as a reasonable insurance premium against the potential loss of such a long-range economic benefit."

On the last paragraph of this question: Criteria for commercialization has become much more stringent. These systems require much more verification of their new features to assure licensability, reliability, and cost effectiveness. In addition, a "one-stop" license is needed for a standardized plant, requiring much more design detail than previously. When these criteria were much less stringent in the mid 50's, several LWR power demonstrations were completed before commercialization occurred. On the other hand, the industry responses have been provided in the context that fiscal pressures prevent the up front outlay of several billion dollars for full scale demonstrations and that substantial cost sharing by the industry would be needed. If Congress worked to infuse major increases in funding with only nominal private funding participation, their action would be applauded by the industry. If the LMR and HTGR become competitive with the LWR after completion of those full scale demonstrations and their subsequent commercialization, the industry would be grateful for the flexibility of choice afforded and the prospects for the earliest use of their unique features to fulfill the complete potential of nuclear power.

McClure:

4. EPRI has provided very little support to HTGR work in the past, despite favorable utility interest in this technology. What would it take to cause EPRI to champion the Modular HTGR?

Taylor:

4. Because of the highest priority given to the "drive for excellence" for the present U.S. nuclear power plants, the success of which is considered a prerequisite to open the nuclear power option in any form, EPRI spends over 90% of its nuclear power R&D on the present systems. The remaining nuclear power R&D funds are used to support the ALWR, LMR, and HTGR. A larger fraction goes to ALWR because of the aforementioned position that industry should provide a greater cost share in ALWR development than LMR and HTGR. Further, a small group of utilities separately support HTGR so that total HTGR utility funding is very close to ALWR utility funding at this time.

GERALD G. FAIN
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Senator Wendell H. Ford
Chairman
Subcommittee on Energy Research
and Development
Committee on Energy and
Natural Resources
Washington, DC 20510-1701

June 13, 1988

Attention: Mary Louise Wagner

Dear Mr. Chairman:

I am pleased to submit on behalf of Mr. John W. Landis the responses to questions submitted as a follow-up to your hearing on May 24, 1988. If we may be of further assistance, please do not hesitate to contact me.

Very truly yours,

Gerald G. Fain

Enclosure
Answer to follow-up questions

Followup Questions
For John Landis, Stone & Webster Engineering Corp.
From Senator Bennett Johnston

Johnston: One of the main findings of the Energy Research Advisory Board's nuclear power panel was that scarce resources were focused too much on defense and space missions that were of little benefit to civilian applications. That trend within the Department's nuclear R&D budget appears to be continuing.

— What should we do about this problem?
— How would you restructure the Department's program to resolve the conflict between defense and civilian needs?
— If this trend is allowed to continue, and the two programs continue to compete for the same dollars, won't the defense side always win?

Landis: Appropriate funds specifically for development of civilian nuclear power. Make sure that the defense nuclear programs pay their fair share of facility and equipment costs at the national laboratories.

Break the reactor-development program into two segments — one for civilian-reactor R&D, the other for military-reactor R&D. Have these segments report to two different Assistant Secretaries.

The defense side would win in almost every case.

Johnston: Should there be a demonstration of one of the three reactor systems?
— Should the federal government support such a demonstration?
— Would the utilities and industry be willing to go in on a 50-50 cost sharing arrangement?

Landis: In proper sequence, all three reactor systems should be demonstrated.

In the case of the ALWR, a full-scale plant demonstration is not needed but new features probably will require testing and evaluation. The federal government should support each of these demonstration projects to an appropriate extent: minimally for the ALWR but with a major share for the MHTGR and LMR. It is very unlikely that the utilities and industry would be able to cost share to any major extent for the MHTGR and LMR demonstrations.

Johnston: Is there a clear near-term option of choice for the next reactor order, or next generation of reactors?
— Isn't the advanced light water reactor likely to be the next reactor built by a utility?
— Realistically, how far into the future is the next reactor order?

Landis: The clear choice for the next series of nuclear power plants is the ALWR being readied under the aegis of the EPRI/industry/DOE program. A reactor order could be expected in four to six years.

Johnston: Realistically, in what time frame would a utility build a liquid metal reactor or HTGR?
— Under what circumstances, and on what terms?

Landis: A demonstration MHTGR might well be designed and built in the decade 1995 to 2005. A demonstration LMR could conceivably be designed and built in about the same time frame.

Johnston: Is legislation necessary to focus the Department's R&D program?
— In your view, what would be the essential pieces of such legislation?
— Would the clean coal demonstration program be a good model?

Landis: Yes, I believe legislation is necessary. The provisions that I suggest be included in any Advanced Reactor Development Act are summarized in pages 10 through 12 of my testimony at the May 24, 1988, hearing. In part the clean coal demonstration program could be a model. However, one must bear in mind that the infrastructure of the nuclear power industry is substantially different from that of the coal-power industry, that the risks involved in nuclear power development are greater than those for coal-power development, and that the supporting federal facilities for reactor R&D are considerably more expensive and complicated than those for coal R&D.

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